May 26, 2022

LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY
Public Participation Group
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EPA Region 6 Main Office
1201 Elm Street, Suite 500
Dallas, Texas 75270
Submitted via email

Re: Public comment and public hearing request on proposed 2022 Annual Monitoring Network Plan by Sierra Club, Healthy Gulf, and Louisiana Bucket Brigade

On behalf of our members and supporters who live, work, and recreate in Louisiana, Sierra Club and its Delta Chapter, Healthy Gulf, and Louisiana Bucket Brigade ("Commenters") respectfully submit these comments regarding the Louisiana Department of Environmental Quality ("LDEQ") proposed 2022 Annual Monitoring Network Plan.

Because the proposed 2022 Annual Monitoring Network Plan is a revision to Louisiana's State Implementation Plan, it should be subject to notice and comment rulemaking, including a public hearing. Therefore, Commenters request that LDEQ hold public hearings to receive additional public comment.

There is a pressing need for many additional monitoring stations across Louisiana. Due to concentrated industrial operations, drastically expanding liquified natural gas facilities, and persistent unauthorized emissions, communities in the Lake Charles area urgently need enhanced nitrogen dioxide air quality monitoring. Similarly, southeast Louisiana communities are subject to predicted nitrogen dioxide pollution but lack air quality data to protect their health and to require stronger protections from polluting industries. Communities along the Gulf Coast, including in the Lake Charles area and in and around Plaquemines Parish, are facing new air quality challenges as oversupply of oil and gas has fueled a refining and petrochemical industry expansion. These communities deserve to know what is in the air, too. Finally, the current monitoring network is insufficient to capture a realistic picture of peak sulfur dioxide emissions around R.S. Nelson, Big Cajun II, and Brame Energy Center. LDEQ must reassess its monitoring network to address these shortfalls.

Commenters urge LDEQ not simply to look at federal standards, which provide mere minimum criteria, but also pressing public health threats to assess the air quality monitoring needs of all Louisianans.

Respectfully submitted,

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COMMENTS OF SIERRA CLUB, HEALTHY GULF, AND LOUISIANA BUCKET BRIGADE ON LOUISIANA'S 2022 ANNUAL MONITORING NETWORK PLAN

I. Background: Air quality monitoring network requirements

The federal Clean Air Act ("CAA" or "Act") requires Louisiana to establish and maintain an air quality monitoring network. This monitoring plan must be included in the applicable State Implementation Plan ("SIP"). 42 U.S.C. § 7410(a)(2)(B). Louisiana's network must meet three design objectives: "(a) Provide air pollution data to the general public in a timely manner … ; (b) Support compliance with ambient air quality standards and emissions strategy development … ; [and] (c) Support for air pollution research studies…" 40 C.F.R. Part 58 App. D ¶ 1.1.

Crucially, monitoring data are used to determine whether areas are in compliance with National Ambient Air Quality Standards ("NAAQS"). 40 C.F.R. Part 58 App. A ¶ 1.1(a). The U.S. Environmental Protection Agency ("EPA") has established NAAQS for only six criteria pollutants: ozone (O_3), particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), lead (Pb), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2). To determine whether an area meets a NAAQS, EPA compares monitoring data to the NAAQS. 40 C.F.R. Part 58 App. D ¶ 1.1(b). Areas that fail to meet a NAAQS are subject to more stringent public health protections under the Act. For example, St. Bernard Parish is in nonattainment with the 2010 sulfur dioxide standard.[1] As a result, more major sources of SO_2 pollution in St. Bernard will have to obtain federal operating permits, and these polluters will have to reduce their SO_2 emissions or secure offsets to more than offset the new pollution they will emit. 42 U.S.C. §§ 7503, 7511a.

Each year, Louisiana must demonstrate compliance with federal minimum monitoring requirements. 40 C.F.R. § 58.10(a)(1), (b). The monitoring network plan must include detailed information about the network's design, including the exact location of each monitor in the network, how each monitor operates, and proposed changes to individual monitors. 40 C.F.R. § 58.10(b)(1)-(5), Part 58 App. D. EPA determines whether the plan meets minimum network design criteria, and the Regional Administrator may require additional information. 40 C.F.R. § 58.10(a)(1). EPA also has authority to order changes to a plan. 40 C.F.R. § 58.14(b). Plans that propose new monitoring sites or other modifications, like the LDEQ plan here,[2] must be approved or denied by the Regional Administrator within 120 days of submission. 40 C.F.R. §§

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[1] U.S. Envt'l Protection Agency, *Louisiana Nonattainment/Maintenance Status for Each County by Year for All Criteria Pollutants*, https://www3.epa.gov/airquality/greenbook/anayo_la.html (last updated April 30, 2022).

[2] The 2022 monitoring plan includes, among other things, shutting down and/or relocating at least two Temporary Located Community monitors and thus requires EPA approval. 2022 Louisiana Air Monitoring Plan at 4; *see also* 40 C.F.R. § 58.10(a)(2) ("Any annual monitoring network plan that proposes network modifications (including new or discontinued monitoring sites . . .) to SLAMS networks is subject to the approval of the EPA Regional Administrator . . ."); 40 C.F.R. § 58.1 ("The SLAMS includes . . . all other state or locally operated criteria pollutant monitors, operated in accordance to this part, that have not been designated and approved by the Regional Administrator as SPM stations in an annual monitoring network plan.").

58.10(a), (e), 58.11(c), 58.14. Thus, after this comment period, LDEQ must submit the plan to EPA for authorization.

Federal regulations prescribe only minimum design criteria for State and Local Area Monitoring Stations ("SLAMS") networks to monitor for criteria pollutants, leaving room for states to establish enhanced air monitoring as areas in their states may require. *See* 40 C.F.R. § 58.1; *see also* 40 C.F.R. Part 58 App. D ¶¶ 4.1-4.8.1 (establishing "Pollutant-Specific Design Criteria" for monitoring networks). SLAMS networks are a collection of devices in various locations that sample the ambient air (or outdoor air) to detect the level of a particular pollutant.[3] The design of a monitoring network—the number of monitors, their specific placement, how frequently they take samples—is critical to getting accurate and representative results. *See generally* 40 C.F.R. Part 58 App. D (establishing mandatory "Network Design Criteria for Ambient Air Quality Monitoring"). Because different pollutants and standards are especially sensitive to particular design criteria, such as the choice of monitor location, EPA provides monitoring network design guidance documents.[4] In part, the purpose of the network is "to provide support to the [SIP], national air quality assessments, and *policy decisions*." 40 C.F.R. § 58.2(a)(5) (emphasis added); *see also* 40 C.F.R. § Pt. 58, App. D ¶ 1.1. Thus, network design and operating procedures are critical to assessing compliance with the public health goals of the Clean Air Act and for state and regional air quality planning efforts.

Apart from Act compliance, there are other uses for air quality data that call on Louisiana to enhance its monitoring network for the protection of public health. Federal regulations envision members of the public making use of publicly available air quality data—the regulations themselves require data dissemination in urban centers, 40 C.F.R. § 58.50, and EPA maintains daily reports via AirNow, available at https://airnow.gov/.[5] Moreover, the network should include monitors that will determine "the highest concentrations expected to occur in the area covered by the network" as well as measure "typical concentrations in areas of high

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[3] A map of the Louisiana air monitoring network is available here: https://experience.arcgis.com/experience/1bc3c0ad43be455ab7224f0324aabaf2/.

[4] *See, e.g.*, EPA, Guidance for Network Design and Optimum Site Exposure for PM2.5 and PM10 at 2-7 (1997), available at: https://www3.epa.gov/ttn/amtic/files/ambient/pm25/network/r-99-022.pdf ("A PM sampler location, especially its proximity to local sources, can play a large role in its ability to assess spatial variability and source contributions"); *see also* EPA, Guidance for Using Continuous Monitors in PM2.5 Monitoring Networks at 6-1 to 6-2 (1998), available at https://www3.epa.gov/ttnamti1/files/ambient/pm25/r-98-012.pdf (discussing the difference between Community Representative or "CORE" PM2.5 monitors located where people live, work and play in comparison to hot spot monitor sites "located near an emitter with a microscale or middle-scale zone of influence" and Special Purpose Monitors ("SPMs") "used to understand the nature and causes of excessive concentrations measured at [CORE] or hot spot compliance monitoring sites."); *see also* EPA, Photochemical Assessment Monitoring Stations Implementation Manual at 2-6 (1994), available at https://www3.epa.gov/ttn/amtic/files/ambient/pams/b93-051a.pdf ("Site selection is one of the most important tasks associated with monitoring network design and must result in the most representative location to monitor the air quality conditions being assessed.").

[5] AirNow data is also shared with and broadcast by major media outlets that disseminate air quality forecasts to individuals. *See* https://www.airnow.gov/index.cfm?action=ani.airnowUS (AirNow "[d]istributes air quality forecasts and data with The Weather Channel, USA Today, CNN, weather service providers, NOAA National Weather Service").

population density" and "air pollution impacts on visibility, vegetation damage, or other welfare-based impacts." 40 C.F.R. § Pt. 58, App. D 1.1.1(a), (b), (f).

II. Public health warrants enhanced NO_2 air quality monitoring in Lake Charles and surrounding communities.

The Gulf Coast of Louisiana has for years experienced a rapid expansion of industrialization. Many areas along the Gulf already experience the consequences of disproportionately high pollution levels. Lake Charles, and Southwest Louisiana more broadly, is an area of concern for high ozone and PM2.5 concentrations. [6] While the Lake Charles area is not currently formally designated as nonattainment for any pollutant, air pollution is a significant concern in the region due to the high number of refineries, petrochemical plants, and oil and gas production facilities.[7]

Recently, the expansion of existing and proposed liquified natural gas terminals along the Gulf coast and especially in Louisiana have increased levels of harmful nitrogen oxides ("NO_x"). NO_x are highly reactive and can cause or worsen respiratory diseases such as asthma. Nitrogen dioxide ("NO_2") is one type of NO_x, and short-term exposure to NO_2 has also been linked to increased asthma-related hospital admissions and emergency department (ED) visits in children and adults), particularly among children and the elderly.[8] Nitrogen oxides are also a precursor for ground-level ozone or smog. Smog is created when nitrogen oxides and volatile organic compounds ("VOCs") such as industrial air pollution that contains benzene react in the presence of sunlight.

While ambient NO_2 concentrations are often elevated near important sources of NO_x emissions, such as major roadways, electric generating units, and other large sources, the highest measured ambient concentrations in a given urban area may not always occur immediately adjacent to those sources.[9] Accordingly, and as EPA explained in the final NO2 NAAQS Rule, it is important to "locate monitors near heavily trafficked roadways in large urban areas and in other locations where *maximum* NO_2 concentrations can occur."[10] One of the major sources of NOx in Louisiana is from the fossil fuel industrial facilities that emit NO_x as a part of daily operations. Given the nature of NO_2, it is important that LDEQ carefully evaluate the optimal NO_2 monitor locations to capture both the highest measured concentrations, and to inform and protect communities that are disproportionately impacted by NO_2 emissions from fossil fuel-burning industry.

As demonstrated in the attached air dispersion modeling report (Exhibit A), which was

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[6] *See, e.g.*, A Green Coalition for Southwest Louisiana, The Path Forward Action Plan (last updated July 2019), available at https://www.epa.gov/sites/production/files/2019-12/documents/update.july_2019.final_.pdf.

[7] *See, e.g.*, Schleifstein, Mark, Louisiana moves two mobile air monitoring labs to Lake Charles, Sept. 3, 2020 available at https://www.nola.com/news/environment/article_14a3585c-ee31-11ea-be71-07cb46c0e2b2.html.

[8] 83 Fed. Reg. 17,226, 17,269 (Apr. 18, 2018).

[9] *Id.* at 17,231.

[10] *Id.* at 17,227 (emphasis added).

conducted using EPA's approved AERMOD dispersion modeling platform, Louisiana's monitoring plan for NO_2 in the Lake Charles area is insufficient to demonstrate compliance with the NAAQS, for several reasons.

a. Rapid expansion of industrial facilities, particularly LNG, in and around Lake Charles raises serious concerns about air quality including NO_2.

Industrial source emissions in the area have or will soon increase since LDEQ's five-year review in 2020, particularly in light of the drastic expansion of liquified natural gas ("LNG") exports in the area. For example, three LNG facilities have been built in the area: Cameron LNG, Calcasieu Pass LNG, and Sabine Pass LNG. In addition, four compressor stations associated with LNG export terminals have been permitted but not yet constructed: the Delfin Onshore Compressor Station, the Driftwood Pipeline Gillis Compressor Station, the East Calcasieu Compressor Station, and the Starks Compressor Station. Five other LNG facilities have been proposed (and permitted) in the area: Commonwealth LNG, CP2 LNG, Magnolia LNG, Driftwood LNG, and Lake Charles LNG. Just across the Texas border, Golden Pass LNG is under construction, which will contribute emissions to the Louisiana airshed. These additions will contribute air pollution in addition to existing sources. Other recently-constructed These additions will contribute air pollution in addition to existing sources. Other recently-constructed compressor stations in the vicinity are the Mermentau Compressor Station and the Lake Arthur Compressor Station. There are numerous other existing industrial sources in the area, some of which include the new Lake Charles Power Station which is next to the existing Roy S Nelson Power Plant, refineries and chemical plants in Lake Charles, and other compressor stations and oil and gas production facilities in the region. Thus, Lake Charles has, and will continue to experience more, significant air emissions in the near future, and it is imperative for protection of public health and welfare that LDEQ ensure the air monitoring network is sufficient to evaluate local compliance with the NAAQS.

Despite this extensive industrial buildout, LDEQ's 2022 monitoring plan includes the bare minimum number of monitors in the Lake Charles area. Federal regulations demonstrate an expectation that more than the minimum number of monitors will be required to achieve monitoring network objectives. 40 C.F.R. § Pt. 58, App. D § 1.1.2 ("The total number of monitoring sites that will serve the variety of data needs will be substantially higher than these minimum requirements provide."). Yet, LDEQ has only 4 monitors, total, in the entire Southwest Louisiana region. Of those, only one—the Westlake monitor—measures NO_2.

b. Recent air dispersion modeling predicts significant exceedances of the 1-hour NO_2 NAAQS in the Lake Charles area.

The attached air dispersion modeling report, which includes both proposed and permitted sources in Cameron and Calcasieu Parishes in Louisiana as well as in Orange County, Texas, demonstrates clear and persistent exceedances of the maximum 1-hour NO_2 standard in and around the Lake Charles area.[11] Indeed, areas of Cameron and Calcasieu Parishes are predicted

[11] The 1-hour NO2 NAAQS takes the form of a three-year average of the 98th percentile of the annual distribution of daily maximum 1-hour concentrations, which cannot exceed 100 parts per billion (ppb). Compliance with this standard was verified using USEPA's AERMOD air dispersion model, which

to exceed ***250 µg/m³***, and parts of Cameron Parish are predicted to exceed ***500 µg/m³*** including background, both well above the 188 µg/m³ standard.[12]

As reflected in the Klafka Commonwealth Report, the continuing, rapid expansion of liquefied natural gas infrastructure is a significant source of those emissions. Although some of these sources are outside of LDEQ's jurisdiction, the agency has an obligation to coordinate with other states that may be causing unhealthy air conditions in Louisiana to develop emissions reductions strategies necessary to ensure attainment of the NAAQS.[13] Louisiana should also more carefully examine and comment on proposed permits in Texas that are likely to impact Louisiana air quality.[14] And if Texas fails to impose limitations on sources with the state, Louisiana should explore other opportunities for compelling Texas to reduce NO_2 emissions that affect Louisiana air quality.[15]

While some of the pollution impacting the Lake Charles area is from Texas sources, Louisiana sources are undoubtedly responsible for a significant share of that pollution, and Louisiana must ensure its monitoring network is sufficient to "[s]upport compliance with ambient air quality standards and emissions strategy development." 40 C.F.R. § Pt. 58, App. D ¶ 1.1(b). If air quality monitoring and modeling continues to demonstrate violations of the standard,[16] LDEQ must take steps to redesignate those areas as being in nonattainment with the NO_2 NAAQS. 40 C.F.R. § 51.1205(d). At a minimum, LDEQ must take appropriate action, including requiring adoption of enforceable emission limits to ensure attainment of the NAAQS in Cameron and Calcasieu Parishes or recommending that EPA redesignate the areas to nonattainment.

c. LDEQ's monitoring plan fails to ensure that NO_2 monitors will capture peak predicted concentrations, as required.

LDEQ's monitoring plan fails to demonstrate that the current NO_2 monitors are placed in a location and manner that captures the peak predicted NO_2 emissions concentrations, as required by EPA regulations.[17] For instance, LDEQ must place monitors in a location that will capture the

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produces air concentrations in units of µg/m3. The 1-hour NO2 NAAQS of 100 ppb equals 188 µg/m3, and this is the value used for determining whether modeled impacts exceed the NAAQS. The 98th percentile of the annual distribution of daily maximum 1-hour concentrations corresponds to the eighth-highest value at each receptor for a given year.

[12] Exhibit A, Modeling Comments of Steven Klafka, P.E., BCEE, Wingra Engineering, S.C., Commonwealth LNG Cameron Parish, Louisiana, Evaluation of Compliance with the 1-hour NAAQS for NO2 (May 24, 2022) [hereinafter "Klafka Commonwealth Report"].

[13] 42 U.S.C. §§ 7410, 7426.

[14] *Id.* § 7426(a).

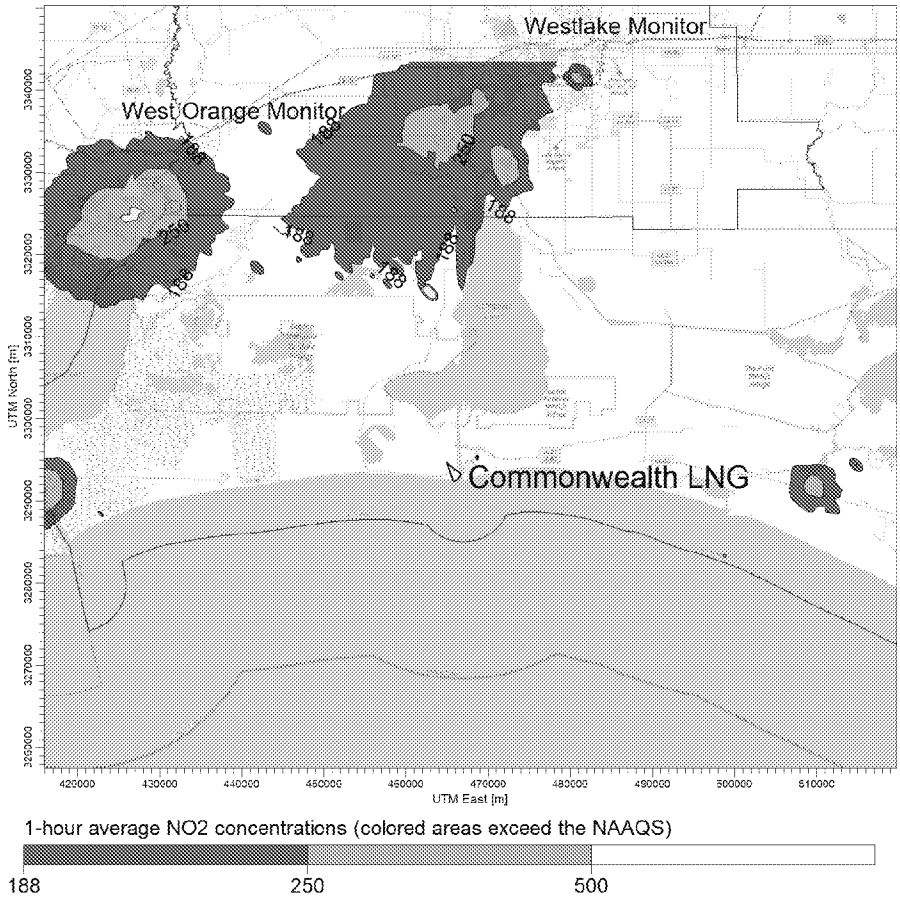
[15] *Id.* § 7426(b).

[16] EPA has clarified that air quality modeling—the use of modeling techniques, databases or computer models to assess impacts to the National Ambient Air Quality Standards—is sufficient and appropriate for demonstrating attainment or nonattainment with the NAAQS. Mem. from Scott Mathias, Director Air Quality Policy Division, EPA, to Regional Air Division Directors Re: Use of Modeling Techniques to Demonstrate General Conformity for Ozone (O3), Fine Particulate Matter (PM2.5) and Nitrogen Dioxide (NO2) (Nov. 13, 2020).

[17] 40 C.F.R. Pt. 58 App. D ¶ 1.1.

peak pollution concentrations caused by a particular source.[18] The attached modeling, which was conducted according to agency protocol and used recent actual and proposed emissions for several permitted sources, demonstrates that LDEQ failed to site monitors in locations with the highest predicted concentration of NO_2 pollution from the respective sources. By way of example, air dispersion modeling conducted according to EPA's NO_2 modeling protocol demonstrates that LDEQ's NO_2 monitor placement for the Lake Charles area does *not* capture peak predicted impacts in the area. Instead, as shown in Figure 1 below, the modeling demonstrates that the highest NO_2 concentrations are in significantly different areas than the existing monitor. *See* Ex. A at 8, Figure 3 (comparing projected 1-hour NO_2 NAAQS exceedances with the location of the Westlake monitor). Notably, the Klafka Commonwealth Report is based on data from TRC Environmental Corporation—conducted on behalf of Commonwealth LNG—which likely significantly underestimated the true impact of Cameron LNG, at a minimum.[19]

Figure 1. Modeled Exceedances of 1-hour NO_2 NAAQS in the Lake Charles area.[20]



[18] *Id.*

[19] *See* Ex. B, Comments of Dr. Ranajit (Ron) Sahu on the Title V Operating Permit No. 0560-00184-V10/PSD-LA-766(M4) for the Cameron LNG LLC Facility, Hackberry, Cameron Parish, Louisiana (Cameron) (Oct. 15, 2021).

[20] Figure excerpted from Klafka Commonwealth Report at 8, Fig. 3.

d. LDEQ's monitoring plan fails to capture impacts on environmental justice communities in the Lake Charles area.

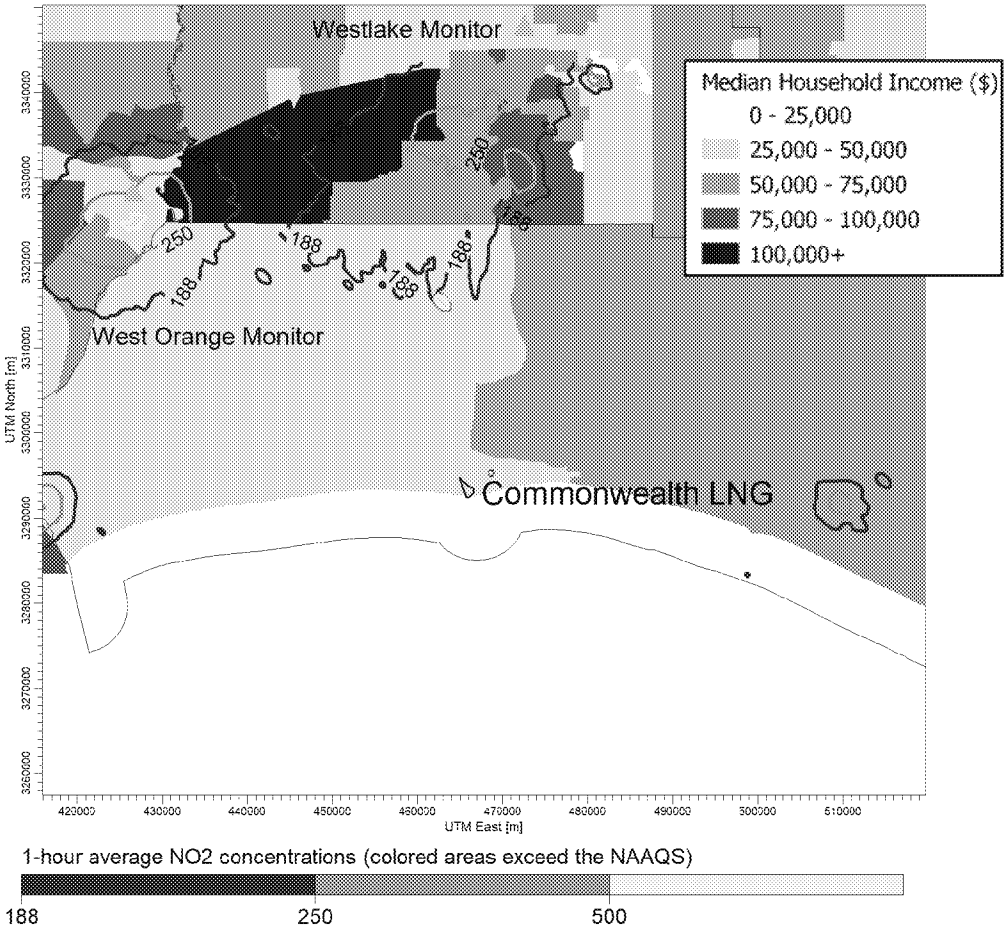
The proper placement of NO_2 monitors in the Lake Charles area is not simply a box-checking exercise—it is critically important for vulnerable communities that have been historically and disproportionately impacted by pollution. As EPA guidance makes clear, the placement of air monitors, particularly NO_2 monitors, should include "a primary focus on siting these monitors in locations to protect susceptible and vulnerable populations."[21] Moreover, additional monitors may be necessary "where an area has the potential to have concentrations that may violate or contribute to the violation of the NAAQS . . . or in locations with susceptible and vulnerable populations, which are not monitored under the minimum monitoring provisions described above."[22] Thus, LDEQ must ensure its air monitoring network accurately captures data regarding impacts to vulnerable populations, particularly those with predicted NAAQS exceedances.

As reflected in the attached Klafka Commonwealth report, and in Figure 2 below, the Cameron Parish communities most impacted by harmful NO_2 exceedances are low income communities. Yet, LDEQ has no NO_2 monitors in Cameron Parish in the proximity of those projected exceedances or the impacted low-income communities.

[21] 40 C.F.R. § Pt. 58, App. D ¶ 4.3.4(a). While the regulations do not define "vulnerable population," EPA's EJScreen tool is intended to help communities and decision makers understand environmental burdens, particularly those faced by vulnerable populations. https://www.epa.gov/ejscreen/frequent-questions-about-ejscreen.

[22] 40 C.F.R. § Pt. 58, App. D ¶ 4.4.3.

Figure 2. Modeled Exceedances of 1-hour NO_2 NAAQS in the Lake Charles area overlaid with median household income.[23]



More generally, as shown in Figures 3 through 6 below, LDEQ has no NO_2 monitors in the lowest income, highest percentage people-of-color, or highest health risk areas located on the eastern and northeastern sides of the city. Nor does LDEQ provide any discussion of analysis demonstrating why its placement of monitors on the western side of town accurately capture data representative of impacts to vulnerable populations.

[23] Figure excerpted from Klafka Commonwealth Report at 10, Fig. 5 (Ex. A).

Figure 3. AirToxScreen Mapping Tool showing elevated relative cancer risk in the Lake Charles area.[24]

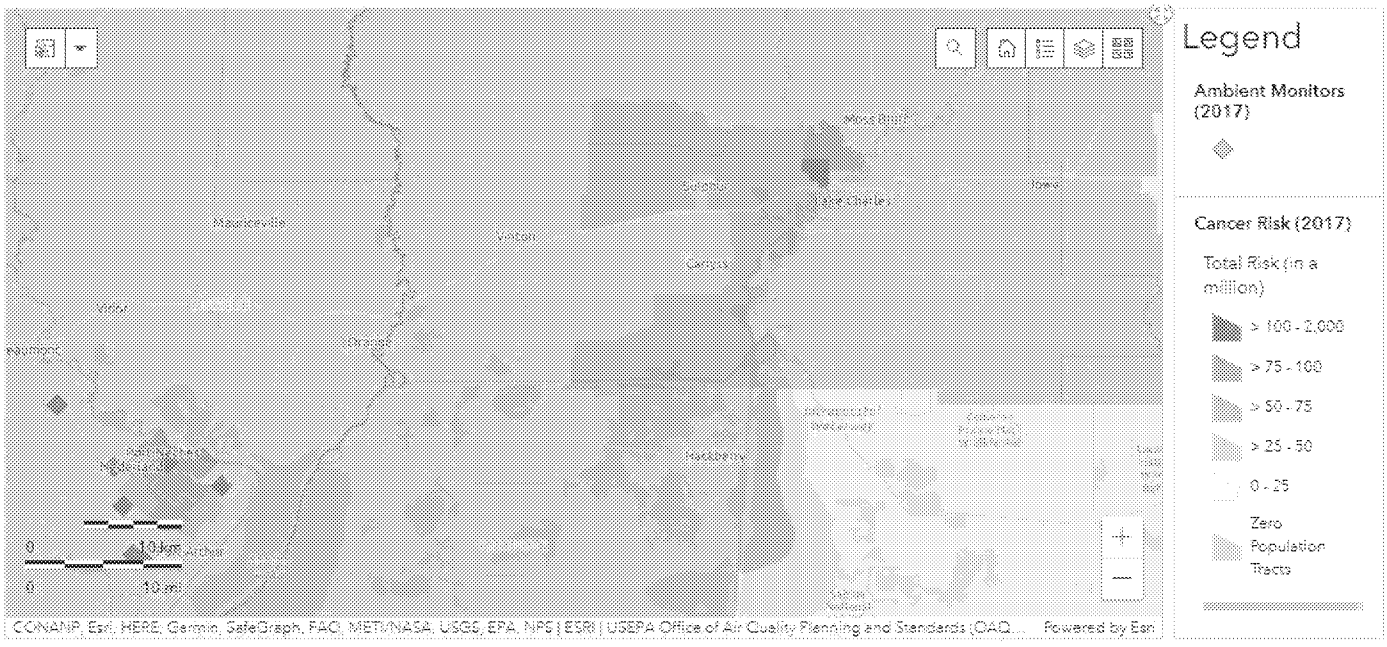


Figure 4. EJScreen map showing high values on the Low Life Expectancy metric on the East and Northeast sides of the Lake Charles area.

[24] Map provided by EPA's AirToxScreen tool, available at https://epa.maps.arcgis.com/apps/dashboards/fb6e6b70c7e2480c8ef88cc8e9c061ac.

Figure 5. EJScreen map showing communities of color located on the north and eastern sides of Lake Charles.

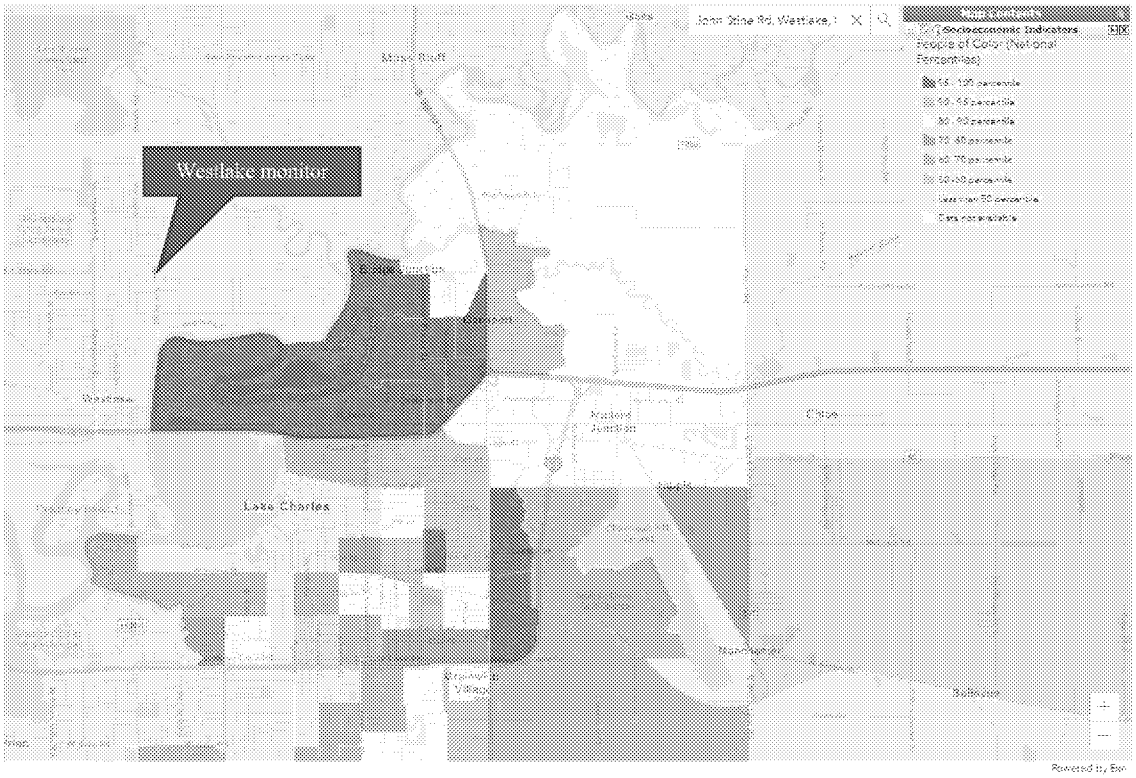


Figure 6. EJScreen map showing communities of color located on the north and eastern sides of Lake Charles.

Therefore, Commenters also urge LDEQ to install additional air quality monitors in those areas to properly characterize ambient air quality and to inform the affected communities.

III. LDEQ Must Increase Monitoring of NO_2 Pollution in Southeast Louisiana.

LDEQ's monitoring network is also insufficient to capture anticipated 1-hour NO_2 NAAQS exceedances in Southeast Louisiana, for similar reasons. **First**, as with the Lake Charles area, there has been a drastic increase in proposed liquified natural gas ("LNG") facilities in and around Plaquemines Parish that is contributing to projected, significant exceedances of the 1-hour NO_2 NAAQS. For example, Venture Global's Plaquemines LNG project is already under construction, and its Delta LNG project has been proposed to the Federal Energy Regulatory Commission. Other proposed LNG facilities nearby include Port Fourchon LNG in Lafourche Parish, New Fortress Louisiana FLNG off of Grande Isle, and West Delta FLNG. [25] Based on modeling provided as part of Plaquemine LNG's air permitting process, the attached Klafka Plaquemines report demonstrates clear and persistent exceedances of the maximum 1-hour NO_2 standard in Acadiana, Jefferson, Lafourche, Plaquemines, and St. Bernard Parishes.[26] Indeed,

[25] https://www.ferc.gov/media/lng-maps-exports.

[26] The 1-hour NO2 NAAQS takes the form of a three-year average of the 98th percentile of the annual distribution of daily maximum 1-hour concentrations, which cannot exceed 100 parts per billion (ppb).26 Compliance with this standard was verified using USEPA's AERMOD air dispersion model, which produces air concentrations in units of µg/m3. The 1-hour NO2 NAAQS of 100 ppb equals 188 µg/m3,

parts of Plaquemines, Jefferson, and St. Bernard Parishes are predicted to exceed ***500 µg/m³*** including background, well above the 188 µg/m³ standard.[27] The maximum projected 1-hour NO_2 impact is nearly **20 times the NAAQS**.[28] Other areas of southeast Louisiana similarly have extraordinary amounts of air pollution, including NOx, such as the industrial corridor between Baton Rouge and the mouth of the Mississippi River in Plaquemines Parish. This stretch of the river is home to over 200 point source industrial polluters. Entergy is proposing a new gas-fired power plant in Iberville Parish, and New Orleans East also has the now infamous gas-fired power plant that is meant to help Orleans Parish be "self-sufficient" as was the gamble made after Hurricane Ida.

Second, despite these predicted NAAQS exceedances, LDEQ's monitoring plan fails to demonstrate that the current NO_2 monitors in southeast Louisiana will capture the peak predicted emissions concentrations, as required by EPA regulations.[29] The attached modeling, which was conducted according to agency protocol and used recent actual and proposed emissions for several permitted sources,[30] demonstrates that LDEQ failed to site monitors in locations with the highest predicted concentration of NO_2 pollution from the respective sources. By way of example, air dispersion modeling conducted according to EPA's NO_2 modeling protocol demonstrates that LDEQ's NO_2 monitor placement for the New Orleans metro area does *not* capture peak predicted impacts in the area. Instead, as shown in Figure 7 below, the modeling demonstrates that the highest NO_2 concentrations are in significantly different areas than the existing monitor. *See* Ex. C at 8, Figure 3 (comparing predicted 1-hour NAAQS exceedances with locations of current monitors).

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and this is the value used for determining whether modeled impacts exceed the NAAQS. The 98th percentile of the annual distribution of daily maximum 1-hour concentrations corresponds to the eighth-highest value at each receptor for a given year.

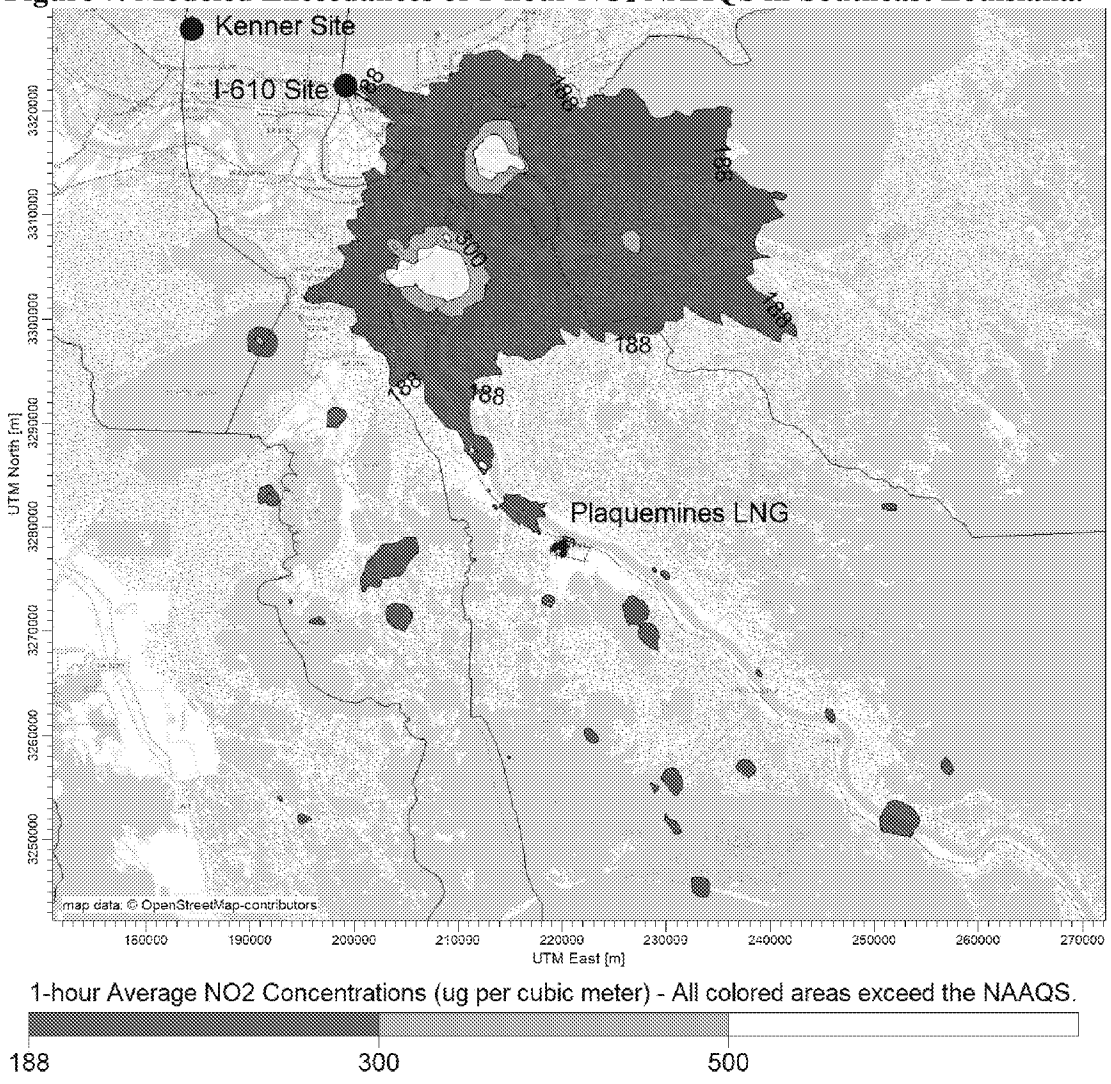
[27] Exhibit C, Modeling Comments of Steven Klafka, P.E., BCEE, Wingra Engineering, S.C., Plaquemines LNG Plaquemines Parish, Louisiana, Evaluation of Compliance with the 1-hour NAAQS for NO2 (May 22, 2022) [hereinafter "Klafka Plaquemines Report"].

[28] Klafka Plaquemines Report at 6 (reporting a maximum projected 1-hour NO_2 concentration of 3,692.8 µg/m3 including background).

[29] 40 C.F.R. Pt. 58 App. D ¶ 1.1.

[30] As with Lake Charles, the attached modeling is based on modeling conducted on the company's behalf and approved by LDEQ as part of the Plaquemines LNG permitting process.

Figure 7. Modeled Exceedances of 1-hour NO_2 NAAQS in Southeast Louisiana.[31]



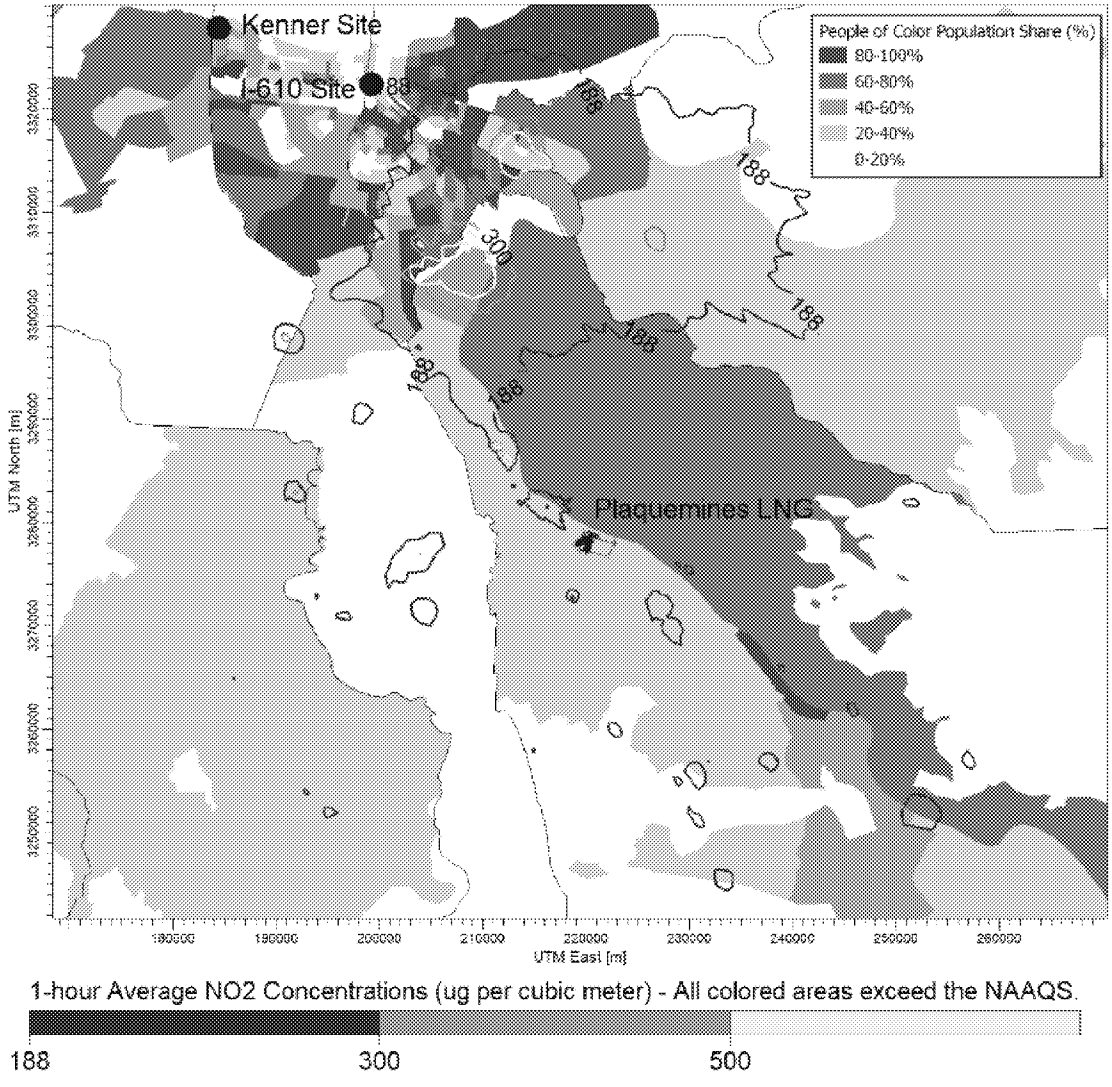
Finally, and importantly, the current monitoring network again fails to provide needed insight into the pollution burden facing environmental justice communities in Southeast Louisiana. As discussed above, EPA regulations make clear that the placement of air monitors, particularly NO_2 monitors, should include "a primary focus on siting these monitors in locations to protect susceptible and vulnerable populations."[32] Moreover, additional monitors may be necessary "where an area has the potential to have concentrations that may violate or contribute to the violation of the NAAQS . . . or in locations with susceptible and vulnerable populations, which are not monitored under the minimum monitoring provisions described above."[33] Thus, LDEQ must ensure its air monitoring network accurately captures data regarding impacts to vulnerable populations and environmental justice communities.

As demonstrated in the Klafka Plaquemines report and shown in Figure 8 below, the

[31] Figure excerpted from Klafka Plaquemines Report at 8, Fig. 3.
[32] 40 C.F.R. § Pt. 58, App. D ¶ 4.3.4(a).
[33] *Id.* ¶ 4.4.3.

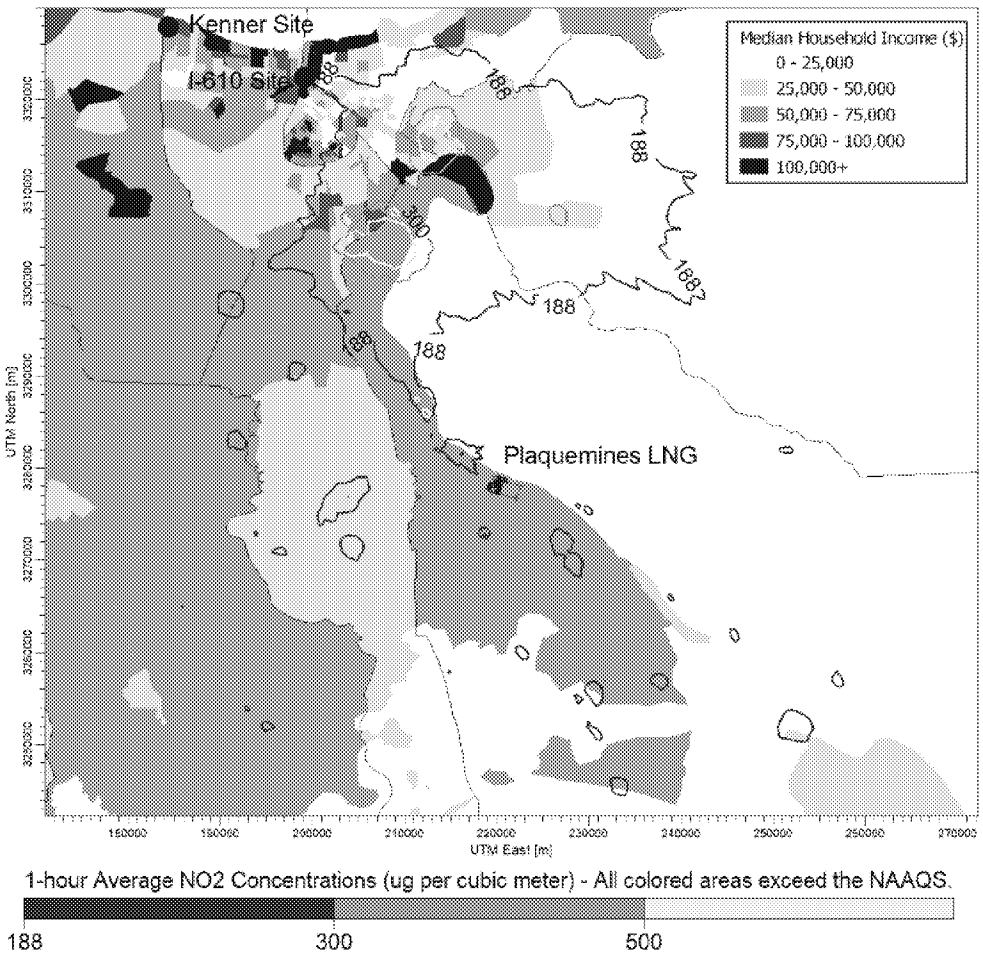
projected NO_2 exceedances will occur primarily in communities of color. Many of the same communities most heavily impacted by the projected NO_2 exceedances are also economically disadvantaged, as shown in Figure 9 below.

Figure 8. Modeled exceedances of 1-hour NO_2 NAAQS in Southeast Louisiana overlapping with communities of color.[34]



[34] Figure excerpted from Klafka Plaquemines Report at 9, Fig. 4.

Figure 9. Modeled exceedances of 1-hour NO_2 NAAQS in Southeast Louisiana overlapping with low income communities. [35]



Despite the substantial overlap between the NAAQS exceedances and communities of color and low-income communities, LDEQ has not proposed any new NO_2 monitors in the vicinity of those impacted communities or otherwise explained why its existing monitoring network is sufficient to capture the rapidly increasing levels of air pollution in Southeast Louisiana. We therefore strongly urge LDEQ to place additional monitors in Plaquemines, Jefferson, and St. Bernard Parishes in these impacted communities.

IV. LDEQ's SO_2 monitoring network is insufficient to support compliance with the 1-Hour SO_2 NAAQS.

To reflect the most current science on SO_2 impacts, in 2010, EPA set the new ambient standard at 75 ppb (196 $\mu g/m^3$) as an hourly average.[36] Due both to its shorter averaging time (1-hour versus 24-hour) and significantly lower allowable concentration (75 ppb versus 140 ppb),

[35] Figure excerpted from Klafka Plaquemines Report at 10, Fig. 5.
[36] 40 C.F.R. § 50.17(a); Primary NAAQS for Sulfur Dioxide, 75 Fed. Reg. 35,520, 35,520-21 (June 22, 2010).

the new standard is considerably more stringent than the prior SO_2 NAAQS. In adopting the 1-hour SO_2 NAAQS, EPA recognized the "strong source-oriented nature of SO_2 ambient impacts." 75 Fed. Reg. at 35,370.

EPA's Data Requirements Rule ("DRR") requires LDEQ to provide data to characterize air quality around many major sources of SO_2.[37] In particular, the rule requires the state to characterize the air quality around sources that emit 2,000 tons per year (tpy) or more of SO_2 and that are not located in an area already designated nonattainment.[38] More specifically, the air agency must submit a list of applicable SO_2 sources that emit more than 2,000 tpy, and notify EPA by January 1, 2016, whether it intends to characterize the "peak SO_2 concentrations" nearby by reference to monitoring or modeling.[39] For each area in which the state wishes to conduct monitoring to determine compliance with the NAAQS, the state must site and operate monitors shall meet applicable criteria in 40 CFR part 58, appendices A, C, and E, and their data shall be subject to data certification and reporting requirements. For any area where SO_2 monitoring was conducted to characterize air quality, the air agency must continue to operate the monitor and shall continue to report ambient data pursuant to existing ambient monitoring regulations, unless EPA approves the decommissioning of the monitor.[40]

For any area where a state used modeling of actual SO_2 emissions serve as the basis for designating such area as attainment for the 2010 SO_2 NAAQS, the air agency shall submit an annual report to the EPA Regional Administrator by July 1 of each year, either as a stand-alone document, or as an appendix to its Annual Monitoring Network Plan (also due on July 1 each year under 40 CFR 58.10), that documents the annual SO_2 emissions of each applicable source in each such area and provides an assessment of the cause of any emissions increase from the previous year. The first report for each such area is due by July 1 of the calendar year after the effective date of the area's initial designation.[41]

Louisiana's annual monitoring plan for SO_2 is insufficient to demonstrate compliance with the NAAQS or the Data Requirements Rule, for several reasons. **First**, LDEQ's proposed annual monitoring plan fails to account for, or monitor, SO_2 pollution from Brame Energy Center, one of the state's largest sources of SO_2. As LDEQ has recognized, Brame is subject to EPA's Data Requirements Rule, and therefore the agency was required to demonstrate compliance with the NAAQS by either submitting EPA-approved modeling or installing and operating a monitor.[42] LDEQ opted, in 2016, to demonstrate compliance through modeling submitted to EPA for review.[43] While that modeling demonstrated initial compliance with the NAAQS, LDEQ's obligations do not end there. As noted, for any area where LDEQ used modeling of actual emissions for demonstrating attainment, the agency is still required to submit annual reports—

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[37] 40 C.F.R. § 51.1202.
[38] *Id.*
[39] *Id.* § 51.1203(a)-(b).
[40] *Id.* § 51.1205(a).
[41] *Id.* § 51.1205(b).
[42] *See* https://www.epa.gov/so2-pollution/so2-data-requirements-rule-january-13-2017-state-submittals-louisiana.
[43] *Id.*

typically as an appendix to the Annual Monitoring Network Plan—documenting annual emissions and assessing the cause of any emissions increase from the previous year.[44] Here, LDEQ's monitoring plan fails to include any such assessment even though SO_2 emissions from Brame increased significantly between 2020 and 2021, the relevant full years of data.[45] According to EPA's air markets database, SO_2 emissions from Brame Energy Center increased from 3,724 tons in 2020, to 5,570 tons in 2021.[46] Despite that increase, LDEQ's annual monitoring plan fails to mention, let alone evaluate the cause, and therefore fails to satisfy the requirements of EPA's regulation. LDEQ's plan is therefore un-approvable and must be amended. We urge LDEQ to install and operate a certified monitor to measure peak SO_2 impacts in the communities surrounding Brame.

Second, LDEQ's proposed annual monitoring plan likewise fails to account for, or monitor, SO_2 pollution from Big Cajun II, another source LDEQ has recognized as being subject to EPA's Data Requirements Rule and for which LDEQ opted to demonstrate initial NAAQS compliance with modeling.[47] As with Brame, LDEQ's monitoring plan fails to assess or even mention SO_2 emissions increases from Big Cajun II, even though SO_2 emissions from the facility increased by approximately 7,000 tons between 2020 and 2021.[48] Given the "source-oriented nature of SO_2 ambient impacts,"[49] LDEQ's existing SO_2 monitors in Baton Rouge, which is more than 17 miles away, cannot accurately detect maximum peak concentrations of SO_2, as required under EPA's regulations.[50] To accurately assess SO_2 concentrations in the areas around Big Cajun II, LDEQ should install and operate a certified monitor.

Finally, the agency's 2022 monitoring plan also fails to demonstrate that the current SO_2 monitors are placed in a location and manner that captures the peak predicted emissions concentrations, as required by EPA regulations.[51] As noted, given the "strong source-oriented nature of SO_2 ambient impacts," EPA regulations contemplate that monitors will be placed near large sources of SO2 in an area that captures peak SO_2 concentrations in the area.[52] Entergy's R.S. Nelson has historically been the largest source of SO_2 pollution in Louisiana, routinely emitting more than 11,000 tons per year.[53] Although emissions from the plant have decreased somewhat over the past two years, the facility still emitted nearly 5,000 tons in 2021, and it has no firm retirement date. Thus, the facility is indisputably subject to the Data Requirements Rule,

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[44] *Id.* § 51.1205(b).
[45] The 2022 air monitoring plan assesses any increase from 2020 to 2021 because a full year of 2022 data is not available.
[46] https://ampd.epa.gov/ampd/
[47] https://www.epa.gov/so2-pollution/so2-data-requirements-rule-january-13-2017-state-submittals-louisiana
[48] https://ampd.epa.gov/ampd/
[49] 75 Fed. Reg. at 35,370.
[50] Under EPA regulations, monitors must be placed in a location that captures "peak" SO_2 concentrations. 40 C.F.R. § 51.1203(a)-(b). Although there is an ozone monitor in New Roads, it does not detect SO_2.
[51] *Id.* at ¶ 1.1(c).
[52] 75 Fed. Reg. at 35,370.
[53] https://ampd.epa.gov/ampd/

yet LDEQ's monitoring placement for the area likely does not capture peak predicted impacts from that source.[54] Indeed, the nearest monitor is almost two miles south, and upwind, of R.S. Nelson making it very unlikely that it captures peak concentrations, as required.[55] LDEQ must reassess the location of the monitor near R.S. Nelson and ensure that it captures peak SO_2 concentrations, and demonstrates compliance with the NAAQS.

V. Conclusion

For the reasons discussed above, LDEQ's 2022 monitoring plan is inadequate and will not properly characterize peak pollution concentrations in many of the most vulnerable communities across the state. To protect the health of Louisiana citizens, LDEQ must enhance its air monitoring network as discussed above.

Commenters further request that the Louisiana Department of Environmental Quality provide a public hearing to address the 2022 air monitoring plan.

Thank you for the opportunity to comment. If you have any questions or need additional information, please do not hesitate to contact us.

[54] LDEQ did not submit modeling to EPA to show compliance with the DRR at R.S. Nelson, and instead opted to demonstrate compliance with monitoring.
[55] *Id.* at ¶ 1.1.

Exhibit A

Commonwealth LNG

Cameron Parish, Louisiana

Evaluation of Compliance with the 1-hour NAAQS for NO_2

May 24, 2022

Conducted by:

Steven Klafka, P.E., BCEE

Wingra Engineering, S.C.

Madison, Wisconsin

1. Introduction

Wingra Engineering, S.C. was hired by the Sierra Club to conduct an air modeling impact analysis to determine if large emission sources were causing exceedences of the 1-hour nitrogen dioxide (NO_2) national ambient air quality standard (NAAQS) in Cameron Parish, Louisiana. This document describes the procedures and results for the evaluation of 926 individual sources of NO_2 located in Cameron Parish and adjacent parishes and county in Louisiana and Texas.

The dispersion modeling analysis predicted ambient air concentrations for comparison with the 1-hour NO_2 NAAQS. The modeling was performed using the most recent version of AERMOD, AERMET, and AERMINUTE, with data provided to the Sierra Club by regulatory air agencies and through other publicly-available sources. The analysis was conducted following all available USEPA guidance for evaluating source impacts on attainment of the 1-hour NO_2 NAAQS via aerial dispersion modeling. This guidance included: the AERMOD Implementation Guide; modeling guidance promulgated by USEPA in Appendix W to 40 CFR Part 51; USEPA's September 30, 2014 memorandum, Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard [1], USEPA's March 1, 2011 memorandum, Additional Clarification Regarding Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS[2], and USEPA's June 28, 2010 memorandum, Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS[3].

To comply with the Prevention of Significant Deterioration (PSD) requirements of the Clean Air Act, TRC Environmental Corporation (TRC) conducted an air quality modeling study on behalf of the Commonwealth LNG liquefied natural gas facility in Cameron Parish, Louisiana.[4] Commonwealth LNG submitted that modeling report to the Louisiana Department of Environmental Quality (DEQ) in October 2021 as part of the PSD permit application. The enclosed modeling analysis updates that evaluation, and provides additional comments.

TRC conducted an analysis to determine if regional sources, including the proposed Commonwealth LNG project, complied with the 1-hour NAAQS for NO_2. The results of the 1-hour NO2 cumulative modeling results were presented in Table 6.2 of the TRC report. The analysis predicted exceedances of the NAAQS. TRC concluded that the Commonwealth project did not contribute significantly to the predicted NAAQS exceedences, so conducted no further evaluation of the predicted NAAQS exceedences.

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[1] https://www.epa.gov/sites/production/files/2020-10/documents/no2_clarification_memo-20140930.pdf
[2] https://www.epa.gov/sites/production/files/2020-10/documents/additional_clarifications_appendixw_hourly-no2-naaqs_final_03-01-2011.pdf
[3] https://www.epa.gov/sites/production/files/2020-10/documents/clarificationmemo_appendixw_hourly-no2-naaqs_final_06-28-2010.pdf
[4] TRC Environmental Corporation, Class II Modeling Report in Support of Part 70 (Title V) Operating Permit and Prevention of Significant Deterioration Permit for Commonwealth LNG, Cameron, Louisiana, October 2021.

It should be noted that the TRC analysis for NAAQS compliance only considered receptor locations where the Commonwealth project was predicted to have a significant impact. Therefore, all locations where violations of the NAAQS may occur would not have been identified.

The enclosed modeling analysis used the same input files as the TRC analysis and were obtained from DEQ. It utilized the same information as accepted by DEQ for the PSD permit application for the Commonwealth LNG project. This information is as follows:

1. Latest version of AERMOD (v21112) with the regulatory default option in the rural mode;

2. Surface and upper-air meteorological data collected at the National Weather Service (NWS) station at the Lake Charles Regional Airport in Lake Charles, LA for the period 2015-2019 to generate AERMOD-ready meteorological data. These data were processed using the most recent version of AERMET (v21112);

3. A fixed background NO_2 concentration was obtained from the ambient monitoring station (Monitor ID 48-361-1001) located in West Orange, Texas.

4. Tier-2 Ambient Ratio Method (ARM2) method to predict the conversion of NO_x to NO_2; and,

5. Regional source inventory of 926 sources of NO_x emissions including the proposed Commonwealth LNG project.

The purpose of this new analysis was to determine the full extent of NAAQS exceedences in Cameron Parish as well as adjacent parishes and counties. For this reason, two change were made to the original modeling files:

1) the modeling domain was extended to the full 50-kilometer distance approved by USEPA for use by AERMOD. This new receptor grid was centered Commonwealth LNG facility.

2) the TRC modeling analysis removed approximately 400 acres of land around Commonwealth LNG from consideration for compliance with the NAAQS. While this land may be owned by the company, there was no description of a fence or other measures that would be employed to preclude public access to the property. Therefore, the updated modeling analysis included receptors on this property.

2. Modeling Results

2.1 1-hour NO_2 SIL and NAAQS

The significant impact level or SIL for NO_2 for the 1-hour averaging period is 7.5 $\mu g/m^3$. This is based on the average of the maximum 1-hour concentrations for each year using five years of meteorology.

The 1-hour NO_2 NAAQS takes the form of a three-year average of the 98th percentile of the annual distribution of daily maximum 1-hour concentrations, which cannot exceed 100 parts per billion (ppb).[5] Compliance with this standard was verified using USEPA's AERMOD air dispersion model, which produces air concentrations in units of $\mu g/m^3$. The 1-hour NO_2 NAAQS of 100 ppb equals 188 $\mu g/m^3$, and this is the value used for determining whether modeled impacts exceed the NAAQS. The 98th percentile of the annual distribution of daily maximum 1-hour concentrations corresponds to the eighth-highest value at each receptor for a given year.

2.2 Commonwealth LNG Facility and Comparison with the Significant Impact Level

The 1-hour average SIL for NO_2 is 7.5 $\mu g/m^3$. If emissions from the Commonwealth LNG facility are predicted to exceed the SIL, the facility is obligated to determine if its emissions combined with those from other regional sources comply with the NAAQS for NO_2. The 2021 analysis by TRC determined that the Commonwealth LNG facility exceeded the SIL so included a NAAQS compliance analysis.

The modeling for comparison with the SIL was updated for the enclosed analysis. The Commonwealth LNG facility was predicted to have a maximum 1-hour average impact of 37.7 $\mu g/m^3$. Since this exceeds the SIL, a NAAQS compliance analysis would be required.

Figure 1 shows the extent in which the Commonwealth LNG facility exceeds the 1-hour SIL of 7.5 $\mu g/m^3$ for NO_2. The SIL was predicted to be exceeded in both Cameron and Calcasieu Parishes. The maximum distance to a SIL exceedance is 40 km.

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[5] USEPA, Additional Clarification Regarding Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS, March 2, 2011.

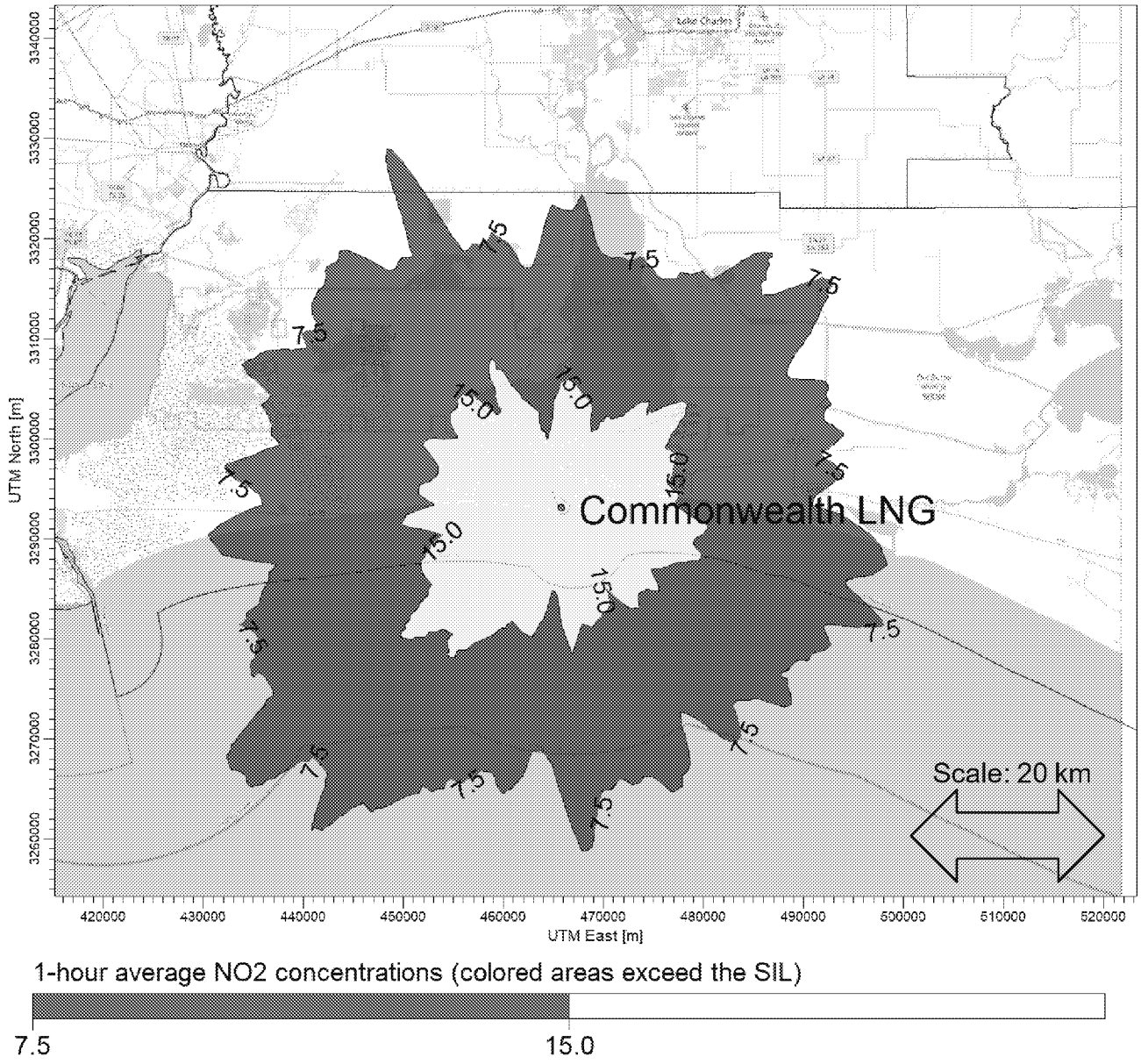

Figure 1 – Exceedences of the 1-hour Average NO_2 SIL by Commonwealth LNG

Table 1 provides the highest Cameron LNG concentrations which exceed the 1-hour SIL. These are the 5-year average of the 1-hour maximum concentrations for unique locations and hours.

Table 1 - Commonwealth LNG Maximum Impacts Exceeding 1-hour Average SIL of 7.5 µg/m³

X	Y	Average	NO_2 Concentration (µg/m³)
463766	3293009	1-HR	37.7
463666	3293009	1-HR	37.6
463766	3293109	1-HR	37.6
463866	3293009	1-HR	37.6
463866	3293109	1-HR	37.6
463666	3293109	1-HR	37.5
463566	3293009	1-HR	37.4
463966	3293109	1-HR	37.4
463966	3293009	1-HR	37.4
463566	3293109	1-HR	37.4

2.3 Compliance with the 1-hour NO_2 NAAQS

The TRC modeling analysis predicted a maximum impact of 229 µg/m³ including background. This exceeded the NAAQS of 188 µg/m³. The greatest distance to receptors exceeding the NAAQS was 39 kilometers.

After expanding the size of the receptor grid and number of receptors, the updated modeling analysis predicted a maximum impact of 1,537 µg/m³ including background. This again exceeded the NAAQS of 188 µg/m³. The greatest length of the area exceeding the NAAQS was 50 kilometers, the full extent of the modeling domain. NAAQS exceedences were predicted to occur in Cameron and Calcasieu Parishes in Louisiana, and in Orange and Jefferson Counties in Texas.

Figure 2 shows the full extent of predicted exceedances of the 1-hour NAAQS for NO_2. Boundaries of parishes in Louisiana and counties in Texas are show in black.

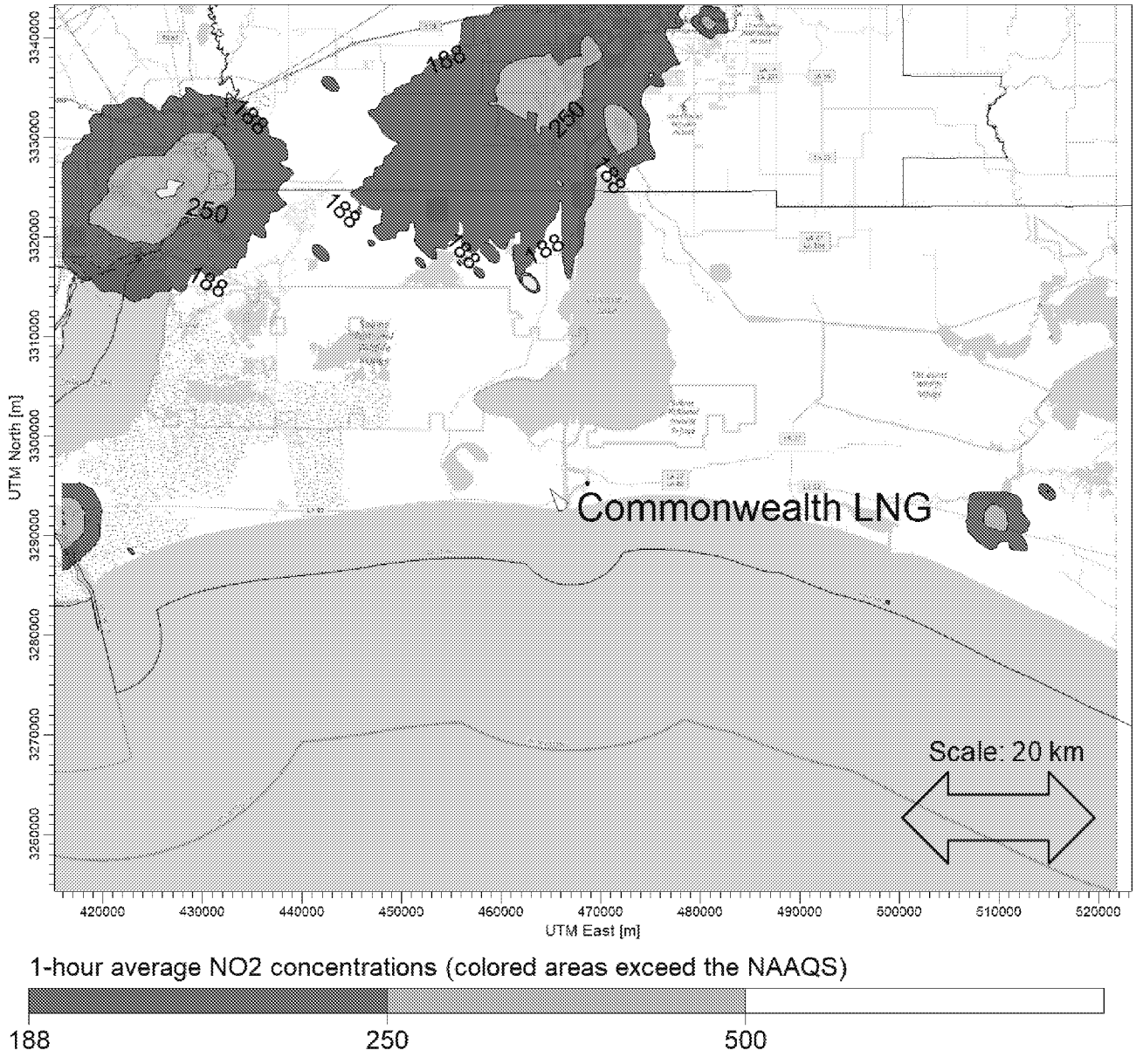

Figure 2 – NAAQS Exceedences by Commonwealth LNG and Regional Sources

2.4 Comparison of Modeling Results and Ambient Monitoring Sites

In the modeling domain there are two existing ambient monitoring sites for NO_2. These are the Westlake Site (Site ID # 22-019-0008) in Louisiana and West Orange Site (Site ID # 48-361-1001) in Texas.

Figure 3 shows the location of the two existing monitoring sites for NO_2 in relation to the areas where the updated modeling study predicted exceedences of the 1-hour NAAQS. The existing monitoring site in Louisiana is not located in the areas with predicted exceedences of the NAAQS. Additional monitors are needed to determine compliance with the NAAQS in these areas predicted to exceed the NAAQS.

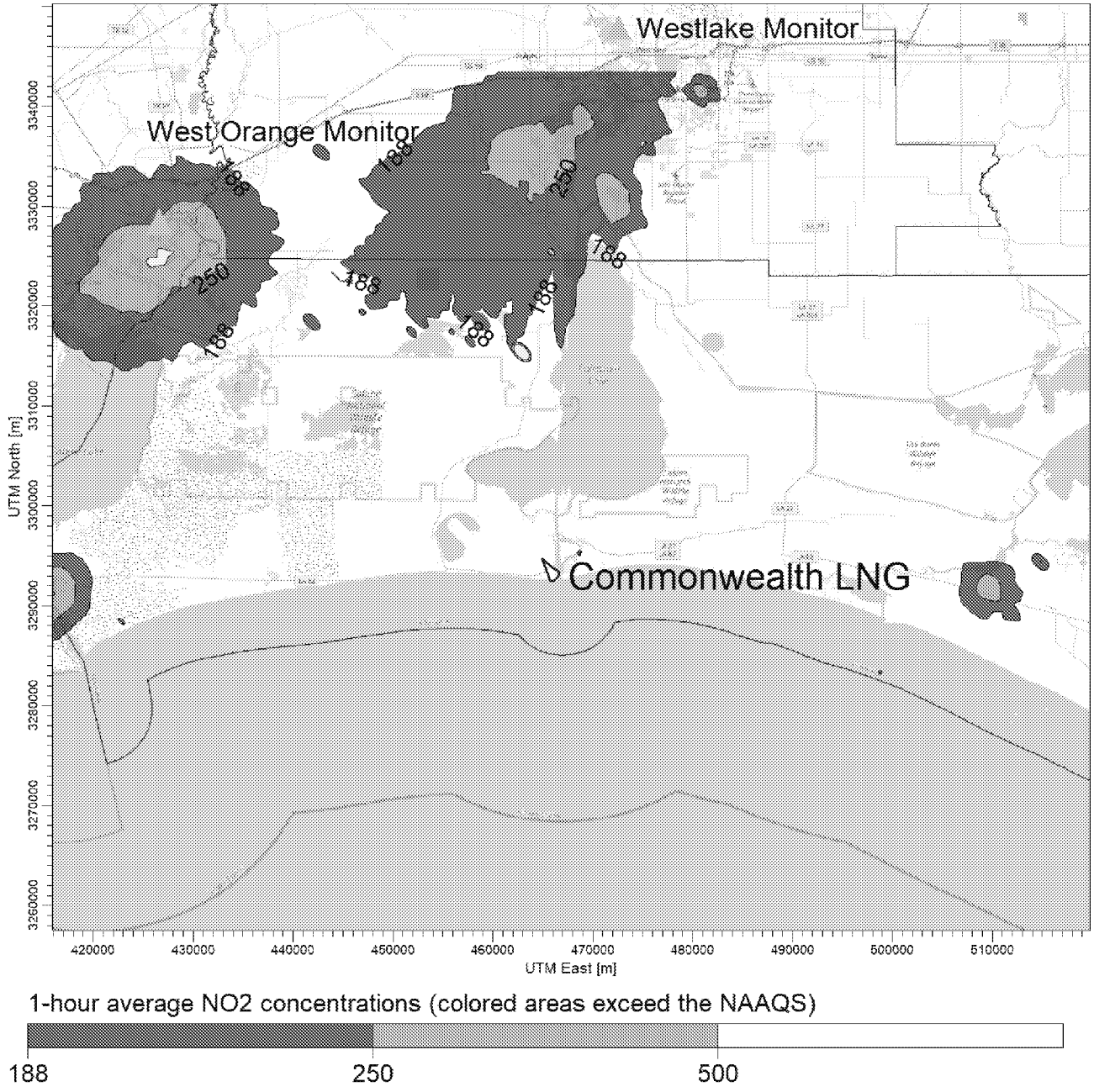

Figure 3 - NO_2 Monitor Locations and Predicted NAAQS Exceedences

Figure 4 shows the location of the two existing monitoring sites for NO_2 in relation to the areas where the updated modeling study predicted exceedences of the 1-hour NAAQS. To evaluate the environmental justice (EJ) impacts of the NAAQS exceedences, the base map for this figure provides the percent people of color in each census tract. The gradations of people of color in the population of each census tract are 0-20% (lightest shade), 20-40%, 40-60%, 60-80%, 80-100% (darkest shade). The existing monitor site in Louisiana is not located in census tracts with a higher percentage of people of color. Additional monitors are needed to determine compliance with the NAAQS in these areas and evaluate EJ impacts.

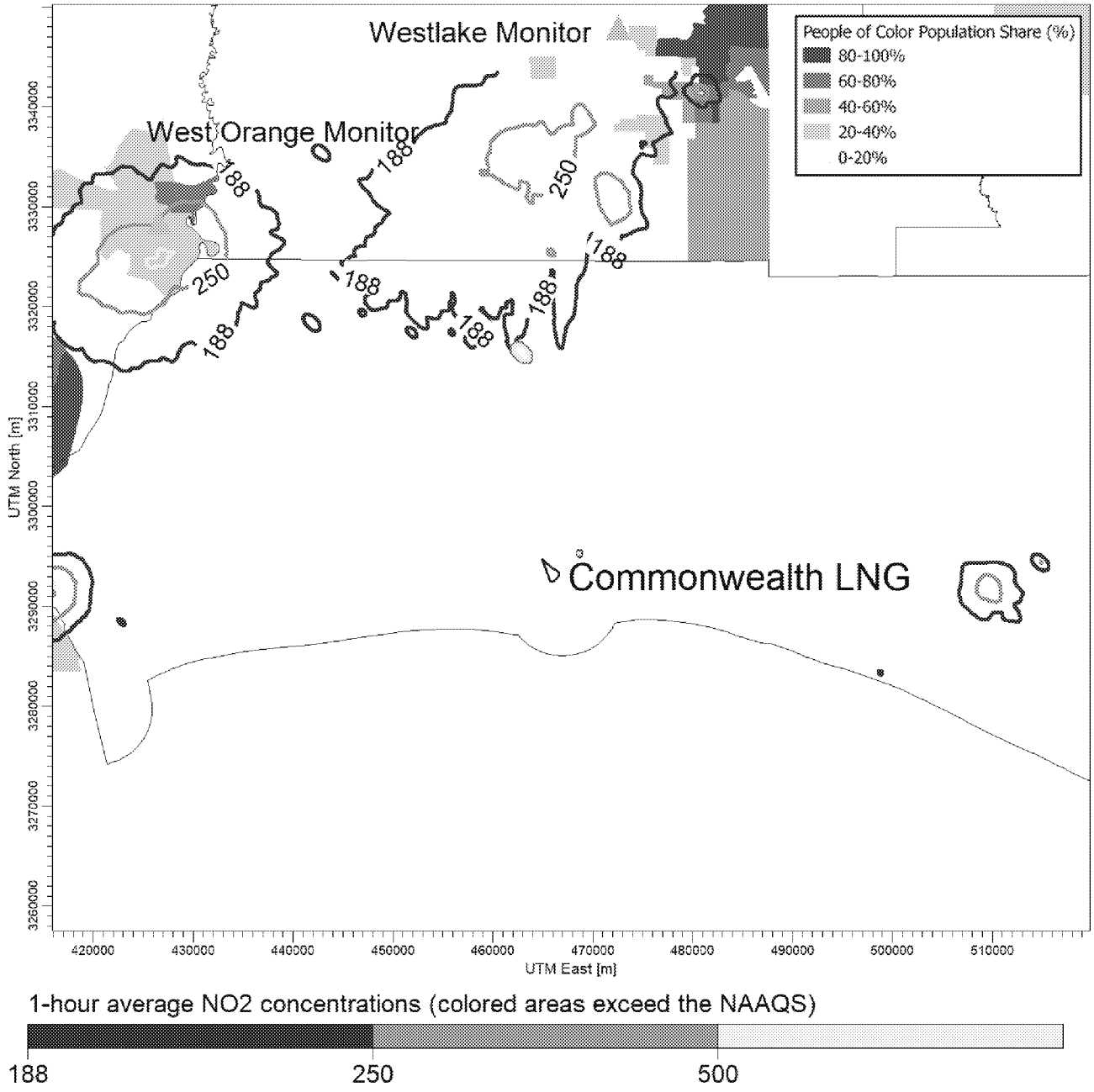

Figure 4 – NO_2 Monitor Locations, Predicted NAAQS Exceedences & People of Color

Figure 5 shows the location of the two existing monitoring sites for NO_2 in relation to the areas where the updated modeling study predicted exceedences of the 1-hour NAAQS. To evaluate the EJ impacts of the NAAQS exceedences, the base map for this figure provides the income levels of residents in each census tract in increments of $25,000 per year. Existing monitor sites are not located in lowest income census tracts. Additional monitors are needed to determine compliance with the NAAQS in the lowest income areas and evaluate EJ impacts.

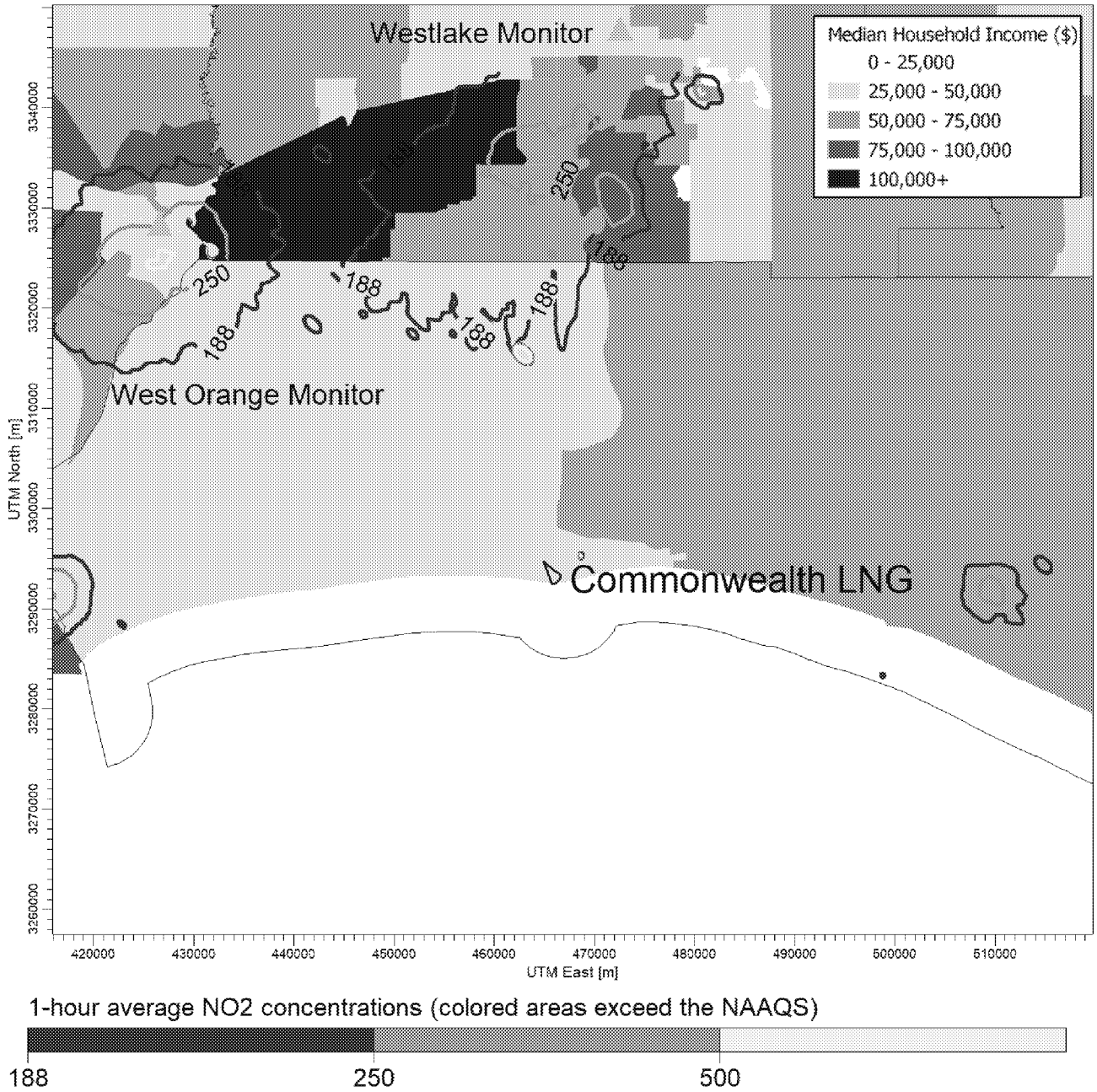

Figure 5 - NO_2 Monitor Locations, Predicted NAAQS Exceedences & Household Income Levels

2.5 Conservative Modeling Assumptions

The modeling results presented in the report may under-estimate NO2 concentrations for the following reasons:

1) The inventory of regional emission sources included substitutions for rates and stack parameters if these were missing or considered inappropriate. These substitutions may underestimate the air quality impact of these sources.

2) The 50-kilometer receptor grid was centered on the Commonwealth LNG facility. Emission sources are located throughout this grid and may individually be culpable for NAAQS exceedences. The receptor grid would need to be centered on each source to fully determine if the source is capable of exceeding the NAAQS.

3) The downwash effect of buildings and structures was evaluated only for the proposed Commonwealth LNG project. It was not considered for the other regional sources. The consideration of downwash may increase in the predicted impacts of the regional sources.

3. Modeling Methodology

3.1 Air Dispersion Model

The modeling analysis used the most recent version of USEPA's AERMOD program, v. 21112. AERMOD, as available from the Support Center for Regulatory Atmospheric Modeling (SCRAM) website, was used in conjunction with a third-party modeling software program, *AERMOD View*, sold by Lakes Environmental Software.

3.2 Control Options

The AERMOD model was run with the following control options:

- 1-hour average air concentrations
- Regulatory defaults

In its October 2021 modeling report, TRC conducted an evaluation to determine if the modeled facility was located in a rural or urban setting using USEPA's methodology outlined in Section 7.2.3 of the Guideline on Air Quality Models.[6] For urban sources, the URBANOPT option is used in conjunction with the urban population from an appropriate nearby city and a default surface roughness of 1.0 meter. Methods described in Section 4.1 were used to determine whether rural or urban dispersion coefficients were appropriate for the modeling analysis.

3.3 Output Options

The AERMOD analysis was based on recent meteorological data. The modeling analysis was conducted using sequential meteorological data from the 2015-19 period. Consistent with USEPA's guidance for evaluation compliance with the NO_2 NAAQS, AERMOD was used to provide a table of eighth-high 1-hour NO_2 impacts concentrations consistent with the form of the 1-hour SO_2 NAAQS.

Please refer to Section 2.0 for the modeling results.

[6] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005.

4. Model Inputs

4.1 Geographical Inputs

The air dispersion modeling analysis used a coordinate system for identifying the geographical location of emission sources and receptors. These geographical locations are used to determine local characteristics (such as land use and elevation), and also to ascertain source to receptor distances and relationships.

The Universal Transverse Mercator (UTM) NAD83 coordinate system was used for identifying the easting (x) and northing (y) coordinates of the modeled sources and receptors. Commonwealth LNG and Cameron Parish are located in UTM Zone 15.

The facility was evaluated to determine if it should be modeled using the rural or urban dispersion coefficient option in AERMOD. A GIS was used to determine whether rural or urban dispersion coefficients apply to a site. Land use within a three-kilometer radius circle surrounding the facility was considered. USEPA guidance states that urban dispersion coefficients are used if more than 50% of the area within 3 kilometers has urban land uses. Otherwise, rural dispersion coefficients are appropriate.[7]

The October 2021 modeling report, TRC evaluated the use of urban vs rural dispersion coefficients. It concluded that rural coefficients were appropriate. A similar approach with rural dispersion coefficients was used for the analysis presented in this report.

4.2 Emission Rates and Source Parameters

The emissions and stack parameters for the 926 sources included in the modeling analysis are summarized in the October 2021 modeling report submitted by TRC to DEQ. Non-Commonwealth source information was obtained by TRC from the DEQ Emissions Reporting and Inventory Center.[8] Additionally, stack parameters for major sources in Texas were obtained by TRC through a Public Information Request to the Texas Commission of Environmental Quality. Procedures for assembling the regional source inventory, as well as all modeling procedures, were described in the October 2021 modeling report submitted by TRC to DEQ.

4.3 Downwash

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[7] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005, Section 7.2.3.

[8] https://business.deq.louisiana.gov/Eric/EricHome

The downwash effect of buildings and structures was considered for only the proposed Commonwealth LNG project. Downwash effects for other regional sources was not considered.

4.4 Receptors

Three receptor grids were employed:

1. A 100-meter Cartesian receptor grid centered on Commonwealth LNG and extending out 5 kilometers.
2. A 500-meter Cartesian receptor grid centered on Commonwealth LNG and extending out 10 kilometers.
3. A 1,000-meter Cartesian receptor grid centered on Commonwealth LNG and extending out 50 kilometers. 50 kilometers is the maximum distance accepted by USEPA for the use of the AERMOD dispersion model.[9]

A flagpole height of 1.5 meters was not used for all modeled receptors.

Elevations for receptors were obtained from National Elevation Dataset (NED) GeoTiff data. GeoTiff is a binary file that includes data descriptors and geo-referencing information necessary for extracting terrain elevations. These elevations were extracted from 1 arc-second (30 meter) resolution NED files. The USEPA software program AERMAP v. 18081 is used for these tasks.

4.5 Meteorological Data

The same meteorological data used for the October 2021 TRC modeling analysis was used for the updated modeling analysis presented in this report. Surface and upper-air meteorological data collected at the National Weather Service (NWS) station at the Lake Charles Regional Airport in Lake Charles, LA for the period 2015-2019 to generate AERMOD-ready meteorological data. These data were processed using the most recent version of AERMET (v. 21112).

Procedures used for processing of the meteorological data would have been evaluated and approved by DEQ as part of the PSD air permit application review process.

4.5.1 Surface Meteorology

Surface meteorology was obtained for Lake Charles Regional Airport in Lake Charles located approximately 41 km northeast the Commonwealth LNG project.

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[9] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, Section A.1.(1), November 9, 2005.

4.5.2 Upper Air Data

Upper-air data are collected by a "weather balloon" that is released twice per day at selected locations. As the balloon is released, it rises through the atmosphere, and radios the data back to the surface. The measuring and transmitting device is known as either a radiosonde, or rawindsonde. Data collected and radioed back include: air pressure, height, temperature, dew point, wind speed, and wind direction. The upper air data are processed through AERMET Stage 1, which performs data extraction and quality control checks.

Concurrent 2015-2019 upper air data from twice-daily radiosonde measurements obtained at the most representative location were used. This location was the Lake Charles Regional Airport measurement station.

4.5.3 AERSURFACE

AERSURFACE is a program that extracts surface roughness, albedo, and daytime Bowen ratio for an area surrounding a given location. AERSURFACE uses land use and land cover (LULC) data in the U.S. Geological Survey's National Land Cover Dataset to extract the necessary micrometeorological data. The current version of AERSURFACE v. 20060. It was used by TRC with National Land Cover Database for 2016 including land cover, canopy and impervious surfaces.

4.5.4 Data Review

Missing meteorological data were not filled as the data file met USEPA's 90% data completeness requirement.[10] The AERMOD output file shows there were 1.0% missing data across the entire 2015-19 meteorological period.

5. Background NO_2 Concentrations

A fixed 1-hour average background NO_2 concentration was obtained from the ambient monitoring station (Monitor ID 48-361-1001) located in West Orange, Texas.

6. Reporting

All files from the programs used for this modeling analysis are available to regulatory agencies.

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[10] USEPA, Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-05, February 2000, Section 5.3.2, pp. 5-4 to 5-5.

Exhibit B

Comments on the

Title V Operating Permit No. 0560-00184-V10/PSD-LA-766(M4)

For the Cameron LNG LLC Facility, Hackberry, Cameron Parish, Louisiana (Cameron)

proposed to be Issued by the

Louisiana Department of Environmental Quality (LDEQ)

by

Dr. Ranajit (Ron) Sahu, Consultant[1]

A. Introduction

I am providing these comments on the Louisiana Department of Environmental Quality's (LDEQ) proposed permit renewals (both Title V and PSD) for the Cameron liquified natural gas (LNG) LLC facility (hereafter, Cameron).

Briefly, as per the various permitting documents in the record, Cameron LNG owns and operates the facility in Hackberry, Cameron Parish, Louisiana. The air emissions from the facility are authorized under a Title V Part 70 Operating Permit No. 0560-00184-V10 and a PSD permit PSD-LA-766(M3). The current action is a renewal of these two permits, the former to -V11 and the latter to version (M4).

Cameron operates the facility to import, store, and re-gasify LNG as well as to liquify natural gas in multiple identical Trains (1-3, which have been constructed,and 4 and 5, which are planned for construction). Each liquefaction Train consists of two refrigeration compressor turbines and associated equipment, such as flares, emergency generators, and water pumps.

In the interest of brevity, I will not repeat additional details of the facility which are described in the various permitting documents, i.e., prior Briefing Sheets, Preliminary Determination Summaries, Statement of Bases, and applications, etc.

B. Documents Reviewed

I have reviewed the following documents relating to the Cameron facility in preparing these comments for the Title V/PSD permit for that facility, with permit numbers as noted in the title:

(i) Title V Renewal Application, September 2, 2020 by Trinity Consultants

(ii) Title V Renewal Application Addendum, March 19, 2021;

[1] Resume provided in Attachment A.

Exhibit A

(iii) Title V Renewal Application Addendum, dated April 27, 2021

(iv) Corrected Proposed Cameron Permit, including: Public Notice; Air Permit Briefing Sheet for Title V Permit (missing page 15 of 15); Statement of Basis for Title V Permit; Briefing Sheet for PSD Permit; Preliminary Determination Summary for PSD Permit; Specific Conditions for PSD Permit;

(v) Various prior versions of Title V and PSD permits (original, M1, M2, and M3);

(vi) Air Dispersion Modeling Report in Support of Permit PSD-LA-766(M1) dated September 9, 2015, prepared by CK Associates; it is my understanding that this was the last time such a modeling analysis has been prepared for Cameron.

C. Documents Referenced in the Record but Not Reviewed

The Specific Condition 1 for proposed permit PSD-LA-766(M4) references an "application dated August 24, 2020," and "additional information dated January 22," 2021. While I have reviewed an application dated September 2, 2020, as noted earlier, I was unable to locate an application dated August 24, 2020, on LDEQ's EDMS database. In addition, while I have seen and reviewed addenda to this application received on March 19 and April 27, 2021, as noted in the same Special Condition, I have not been able to locate the addendum dated January 22, 2021.

D. Comments on Some of the Specific Requests by the Facility

While the permit record notes that a number of changes have been requested to be incorporated into the Title V permit as part of this renewal, I specifically highlight a few of them below, since they affect the emissions estimates and/or dispersion characteristics that underlie these permitting actions, and are the subject of my comments later in this report. After each of the items below, I provide my comments:

(i) Updated stack diameter for EQT0017. I note that this update changes the dispersion characteristics of this source, but neither Cameron nor LDEQ updated the prior (i.e. 2015) dispersion modeling.

(ii) Updated calculations for tanks using the updated AP-42 methodology. I note that all of the emissions calculations, since they are being evaluated for the purpose of New Source Review (NSR), Prevention of Significant Deterioration (PSD),[2] need to be estimated on a Potential-to-Emit (PTE) basis, as that term is defined and used in the NSR regulations. As discussed below, however , AP-42 is not an appropriate basis for estimating the PTE absent any discussion of the

[2] The one exception to this is NOx, where the Non-Attainment New Source Review provisions instead of the PSD provisions should apply. The reason is that Cameron's own 2015 modeling clearly showed that the area around Cameron far exceeds (i.e., over 16 times) the 1-hour NOx National Ambient Air Quality Standards (NAAQS). Just because there are no ambient air quality monitors located in this area and the area has therefore not been designated formally as a non-attainment area, does not mean that the modeling results should simply be disregarded. Thus, for this pollutant, NNSR should apply. This has implications for establishing emissions limits – i.e., that the proper standard should be Lowest Achievable Emission Rate (LAER) as opposed to Best Available Control Technology (BACT). I discuss this later in my comments.

appropriateness and representativeness of the specific emissions factors used. That has not been done in any of the many instances where AP-42 has been used as the basis of emissions calculations for this renewal action.

(iii) Updated the CO emission factor for EQT00017, EQT0079, EQT0083, and General Condition XVII Activities to reflect the latest AP-42 emission factors. Please see the comments on use of AP-42 above and the expanded discussion regarding AP-42 later in the comments.

(iv) Per the March 19, 2021 Addendum, a request to incorporate a startup, shutdown, and maintenance (SSM) scenario which involves the routing of the acid gas streams through the existing PR Refrigeration Turbine stacks (EQT0071, EQT0072, EQT0073, EQT0095, and EQT0096) during maintenance of the thermal oxidizers (TO) (ET0056, EQT0057, EQT0081 and EQT0082). The emissions estimates for this change relied extensively on AP-42. Please see the comments on use of AP-42 above and the expanded discussion regarding AP-42 later in the comments.

As a result of the changed SSM scenario, I note that Cameron stated that "these changes result in an increase in VOC emissions from the entire facility of 37.25 tpy."[3] It also noted that "emission increases are not expected for other criteria pollutants and Toxic Air Pollutants (TAPs) when compared to the Title V Permit Renewal Application submitted in September 2020."[4] A significant portion of these emissions appear to be from estimate SSM periods from EU20, the ground flare, per the table provided in the addendum and shown below for ease of reference.

Source Description:
EU20, Ground Flare - Normal Emissions and SSM Emissions

Total Emissions

	Normal Operation[1]		SSM Operations[2]		Total Emissions	
Pollutant	lbs/hr	TPY	lbs/hr	TPY	lbs/hr	TPY
PM10	0.68	2.97	116.20	28.13	116.20	31.10
PM2.5	0.68	2.97	116.20	28.13	116.20	31.10
Sulfur Dioxide	0.06	0.24	11.71	1.50	11.71	1.75
Nitrogen Oxides	6.19	27.12	1,053.57	242.64	1,053.57	269.76
Carbon Monoxide	28.22	123.62	5,732.66	1,076.58	5,732.66	1,200.20
GHGs (CO_2e)		49,152		469,344		518,495
VOC	2.55	11.17	83.80	23.09	83.80	34.26
n-Hexane	0.20	0.86	26.23	6.15	26.23	7.01
Benzene	---	---	3.23	0.30	3.23	0.30

Note:
1. Emissions from normal operation of the Ground Flare.
2. Emissions from Start up, Shut down and Maintenance of Ground Flare.

As a result of this change, Cameron and LDEQ estimate a 37.25 tons/year increase, which is not appreciably lower than the Significant Emission Rate for VOCs, before triggering PSD is 40 tons/year. Thus, accuracy in the emissions estimation method is paramount. I note that numerous

[3] March 19, 2021 Addendum, at pdf 93 in CORRECTED Proposed Cameron Permit.pdf

[4] *Id.*

assumptions have been made by Cameron in arriving at this increased emissions rate of 37.25 tons/year but none of those assumptions are reflected in the proposed permit – making each of those assumptions unverifiable, and therefore unenforceable. It is my opinion that without requiring Cameron to verify its assumptions, and without imposing strictly enforceable conditions, the proposed SSM scenario change likely exceeds the 40 tons/year PSD threshold. As a result, a BACT assessment would be required for VOCs, which has not been done.

Further, there is no support (i.e., no process data, for example, showing the worst case composition of the acid gas streams in question, including all TAPs that may be present in these streams) for Cameron's statement that there would not be any expected emissions increase for the many TAPs as a result of this change. I note that the permit conditions require no stack testing or other monitoring to verify this assertion.

(v) Per the April 27, 2021 Addendum, Cameron requested a "permanent change in the butane pump seals which involves the seal vent gas being routed to the LP Wet Flare Line of Ground Flare (EQT0079) continuously."[5] Cameron also noted that "[T]his modification requires physical changes and changes in the method of operation. These changes will result in a small increase in NOx, CO, VOC and CO2e emissions from the entire facility. Emission increases are less than the significant emission rate (SER) under the Prevention of Significant Deterioration (PSD) rules."[6] Again, these emissions increases are dependent on numerous assumptions and the use of inappropriate emission factors. Please see comments on item (iv) above relating on lack of enforceability, and comments on the use of AP-42 emission factors throughout this report.

(vi) Update the Global Warming Potential (GWP) for GHGs per the latest regulation (40 CFR 98) for EQT000l - EQT0010, EQT0016, EQT017, EQT0020, EQT0021, EQT0022, EQT0041, EQT0042, EQT0043, EQT0047, EQT0048 and GRP0002. I note that the Part 98 GWPs are outdated (i.e., reflect the consensus as of 2007) and do not reflect the most current consensus science (i.e., the updates since, including in 2013 and also most recently in 2021) which are contained in the more recent Intergovernmental Panel on Climate Change (IPCC) reports.[7] The 2007 GWPs were contained in the Fourth Assessment Report (AR4) of the IPCC. The 2013 was the Fifth Assessment Report (AR5) and the most recent update is the Sixth Assessment Report (AR6). It is important to note that the purpose of the Part 98 regulations was for emissions reporting and not for use in permitting actions.

(vii) In my review, I came across numerous references to vendor data or similar in the permit applications. One example is referenced in the table reproduced immediately below, at Note 1.

[5] April 27, 2021 Addendum, at pdf 122 in CORRECTED Proposed Cameron Permit.pdf

[6] *Id.*

[7] See https://www.ipcc.ch/

EU15A/B/C/G/H, Refrigeration Compressor Turbines (Mixed Refrigerants)

Hazardous/Toxic Air Pollutants (HAPs/TAPs)		See Note 3	Average Lbs/Hr	Maximum Lbs/Hr	Annual TPY	Calculation Methodology (lbs/hr)
1,3-Butadiene	4.30E-07	lbs/MMBtu	< 0.001	<0.001	0.004	[illegible]
Acetaldehyde	4.00E-05	lbs/MMBtu	0.04	0.05	0.19	[illegible]
Acrolein	6.40E-06	lbs/MMBtu	0.01	0.01	0.03	[illegible]
Benzene	1.20E-05	lbs/MMBtu	0.01	0.02	0.06	[illegible]
Ethylbenzene	3.20E-05	lbs/MMBtu	0.03	0.04	0.15	[illegible]
Formaldehyde	7.10E-04	lbs/MMBtu	0.76	0.91	3.32	[illegible]
Naphthalene	1.30E-06	lbs/MMBtu	0.001	0.002	0.01	[illegible]
PAH	2.20E-06	lbs/MMBtu	0.002	0.003	0.01	[illegible]
Propylene Oxide	2.90E-05	lbs/MMBtu	0.03	0.04	0.14	[illegible]
Toluene	1.30E-04	lbs/MMBtu	0.14	0.17	0.61	[illegible]
Xylene	6.40E-05	lbs/MMBtu	0.07	0.08	0.30	[illegible]
Sulfuric Acid Mist (H_2SO_4) [4]	1.60E-01	Lbs/hr	0.01	0.02	0.06	[illegible]
CO2e	**Mass Flow (lbs/hr)**	**Lbs/MMBtu**	**544,550**	**Annual TPY**		**Emission Factor References**
Carbon Dioxide	124,914	------	544,498	TPY		Engineering estimate
Methane		0.0088	40	[illegible]		AP 42, Chapter 3, Table 3.2-1a
Nitrous Oxide		0.0030	14			AP 42, Chapter 3, Table 3.2-1a

REFERENCES/NOTES

1. Emission factors are based on vendor data.
2. A safety factor of 1.3 is used to calculate maximum emissions for all pollutants except for NOx which uses a safety factor of 1.05.
3. HAP/TAP emission factors (except H_2SO_4) are based on EPA AP-42, Section 3.1, Table 3.1-3, Emission Factors.
4. Assumes 5% of the sulfur in the fuel is converted to SO3 and 100% will react with water vapor to form Sulfuric Acid (H_2SO_4) Mist.

However, I could not find any such vendor data in the various modification and/or renewal applications. Given that these "vendor" data are not provided, it is not clear, therefore, what sources were used, and in what manner.

(viii) Lastly, I should mention that large portions of the permitting documents, especially the applications and the emissions calculations details are barely legible. This certainly does not facilitate reasonable public review. Given advancements in technology and the ubiquitous nature of Excel and comparable spreadsheet software, LDEQ require sources to submit all emission calculations in native, live (i.e., with all formulas shown), electronic format (i.e., Excel or similar), and should make this available to the public. Numerous other state agencies do this routinely. Not having the emissions calculations in native, live, format raises legitimate issues about the DEQ's own review of the calculations.

To provide context for some of my comments below relating to BACT, it is useful to review the history of the permitting for this facility. I do so in the next section, using the PSD permit history, and focusing on NOx emissions as an example.

E. Confusing PSD Permitting History

PSD-LA-766

The initial PSD permit, PSD-LA-766 was issued on October 1, 2013. The following tables, taken from the supporting documents associated with that permit, such as the Briefing Sheet or the Preliminary Determination Summary as well as from the permit itself show: (i) the emissions summary table for the major, i.e., criteria pollutants; (ii) the BACT Selection table; and (iii) the air quality analysis.

Pollutant	Before	After	Change	PSD De Minimis	PSD Review
$PM_{10}/PM_{2.5}$	72.65	166.97	+ 94.02	15/10	Yes
SO_2	13.59	12.48	- 1.11	40	No
NO_x	473.88	2,567.73	+ 2,093.85	40	Yes
CO	336.12	1,075.52	+ 739.40	100	Yes
VOC	56.97	124.57	+ 67.60	40	Yes
CO_2e	-	3,958,392	3,958,392	75,000	Yes
Lead	-	0.002	+ 0.002	0.6	No

The table above shows that NOx, for example, increased from 473.88 tons/year by over 2,000 tons to 2,567.73 as a result of the addition of Trains 1, 2, and 3 of the liquefaction system.

PSD-LA-766

TABLE III. BACT SELECTION

Equipment	$PM_{10}/PM_{2.5}$	NO_x	CO	VOC	GHG
Turbines	Good combustion practices Fueled by natural gas	DLN & good combustion practices 15 ppmv @ 15% O_2	Good combustion practices and fueled by natural gas 0.040 lb/MM BTU	Good combustion practices and fueled by natural gas	Fueled by natural gas Use high thermal efficiency turbines Good combustion / operating practices
Water Pump & Generator Engines	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	Good combustion / operating practices
Thermal Oxidizers	Good equipment design and proper operating practices Natural gas fuel	Good equipment design and proper operating practices	Good equipment design and proper operating practices Natural gas fuel	Good equipment design and proper operating practices Natural gas fuel	Fueled by natural gas good combustion / operating practices
Flares	Proper plant operations and maintain the presence of the flame at the flare tips when vent gas is routed to the flares				
Condensate Tank				Closed vent and control device that meet 40 CFR 60 Subpart Kb	
Loading Operations				Good equipment design and proper operating practices	
Fugitives				LAC 33:III.2111	LDAR

LAC 33:III.2111: All rotary pumps and compressors handling volatile organic compounds having a true vapor pressure of 1.5 psia or greater at handling conditions shall be equipped with mechanical seals or other equivalent equipment

The BACT summary table shows NOx from the turbines at 15 ppm corrected to 15% oxygen and CO from the turbines at 0.04 lb/MMBtu. None of the other BACT limits had any numerical values.

PSD-LA-766

TABLE II: AIR QUALITY ANALYSIS SUMMARY ($\mu g/m^3$)

Pollutant	Averaging Period	Preliminary Screening	Significant Monitoring	Level of Significant Impact	At Monitoring Station		Background	Maximum Modeled	Modeled + Background	NAAQS	Modeled PSD Increment Consumption	Allowable Class II PSD Increment
					Monitored Values	Modeling Results						
$PM_{2.5}$	24-hour	0.69	4	1.2						35		9
	Annual	0.05		0.3						15		12
NO_2	1-hour	35.4		7.5					(*) 3113	188		
	Annual	0.8	14	1						100		25
CO	1-hour	162.8		2000						40,000		
	8-hour	51.3	575	500						10,000		

NAAQS = National Ambient Air Quality Standards

(*) Project's maximum contribution to an exceedance of the NAAQS is 3.68 $\mu g/m^3$. Project's maximum contribution to the maximum concentration of 3113 $\mu g/m^3$ is 0.00014 $\mu g/m^3$.

Finally, the table above summarizes the results of air dispersion modeling, which clearly must have been completed prior to October 1, 2013. From other portions of the record, that modeling appears to have been completed around May 2013. I have highlighted that for 1-hour NOx, the modeled results show 3113 micrograms per cubic meter, which is more than 16 times the 188 micrograms per cubic meter limit under the NAAQS.

Clearly, the area around Cameron is modeled to be in non-attainment for the 1-hour NOx standard. I am not aware of any new monitoring station installed by either EPA or LDEQ to verify these extremely large NOx impacts in the area. As a result, while there is no formal designation of non-attainment, this modeling shows that any properly sited monitor would likely indicate non-compliance.

One consequence of this is that the NOx BACT analysis was incorrect and the applicant and the LDEQ should have conducted a NOx LAER analysis, even back in 2013.

PSD-LA-766(M1)

Next, PSD-LA-766(M1), the first modification to the initial PSD permit, was issued on June 26, 2014. It shows the initial addition of liquefaction trains 1, 2, 3 in the initial PSD-LA-766 permit and some additional changes. From its Briefing Sheet, the NOx emissions from the facility after M1 was 2586.52 tons per year, per table below, which is somewhat greater than the "After" value in the original PSD permit of 2567.73 tons/year noted prior.

Pollutant	Before	After	Change	PSDDe Minimis	PSD Review
$PM_{10}/PM_{2.5}$	72.65	168.29	+ 95.64	15/10	Yes
SO_2	13.59	11.84	- 1.75	40	No
NO_X	473.88	2,586.52	+2,112.64	40	Yes
CO	336.12	1,094.93	+ 758.81	100	Yes
VOC	56.97	132.48	+ 75.51	40	Yes
CO_2e	-	3,983,512	+ 3,983,512	75,000	Yes
Lead	-	0.002	+ 0.002	0.6	No

The BACT Selection Table III from PSD-LA-766(M1) is shown below. Note the form of the CO BACT, which is still 0.04 lb/MMBtu as in the original PSD permit. The permit Briefing Sheet and the Preliminary Determination Summary state that BACT was not changed from the initial BACT determination in the PSD-LA-766 permit issued on October 1, 2013. Again, only the NOx and CO limits for the turbine have numerical values in the entire BACT determination.

PSD-LA-766(M1)
TABLE III. BACT SELECTION

Equipment	$PM_{10}/PM_{2.5}$	NO_x	CO	VOC	GHG
Turbines	Good combustion practices Fueled by natural gas	DLN & good combustion practices 15 ppmv @ 15% O_2	Good combustion practices and fueled by natural gas 0.040 lb/MM BTU	Good combustion practices and fueled by natural gas	Fueled by natural gas Use high thermal efficiency turbines Good combustion / operating practices
Water Pump & Generator Engines	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	Good combustion / operating practices
Thermal Oxidizers	Good equipment design and proper operating practices Natural gas fuel	Good equipment design and proper operating practices	Good equipment design and proper operating practices Natural gas fuel	Good equipment design and proper operating practices Natural gas fuel	Fueled by natural gas good combustion / operating practices
Flare	Proper plant operations and maintain the presence of the flame at the flare tips when vent gas is routed to the flares				
Condensate Tanks				Closed vent and control device that meet 40 CFR 60 Subpart Kb	
Loading Operations				Vapor balanced loading Good equipment design and proper operating practices	
Fugitives				LAC 33:III.2111	LDAR

LAC 33:III.2111: All rotary pumps and compressors handling volatile organic compounds having a true vapor pressure of 1.5 psia or greater at handling conditions shall be equipped with mechanical seals or other equivalent equipment

PSD-LA-766(M2)

PSD-LA-766(M2), the second modification, was issued on March 3, 2016. It shows the addition of liquefaction Trains 4 and 5 in addition to previously permitted Trains 1, 2, 3 in the initial PSD-LA-766 permit and some additional changes. From its Briefing Sheet, the NOx emissions from the facility after M2 jumped to 3172.23 tons per year, per table below, which shows the original PSD NOx in the "Before" column, i.e. the same as in the original and M1 permits noted above.

Pollutant	Before	After	Change	PSD De Minimis	PSD Review
$PM_{10}/PM_{2.5}$	72.65	438.43	+ 365.78	15/10	Yes
SO_2	13.59	27.09	+ 13.50	40	No
NO_X	473.88	3,172.23	+ 2,698.35	40	Yes
CO	336.12	3,147.26	+ 2,811.14	100	Yes
VOC	56.97	226.32	+ 169.35	40	Yes
CO_2e	551,389	9,029,617	+ 8,478,228	75,000	Yes
Lead	-	0.002	+ 0.002	0.6	No

The BACT Selection Table III from PSD-LA-766(M2) is shown below. Curiously, even though the Briefing Sheet for M2 states that "BACT for the previously proposed equipment is still valid and will not be re-evaluated…," it is clear that the form of the CO BACT, which is now 15 ppm at 15% O_2 is different than the CO BACT in M1 and the original permits which was 0.04 lb/MMBtu. In addition, there are numerical values for the turbine $PM_{10}/PM_{2.5}$ as well as the turbine VOC BACT determinations. No explanation is provided in the record but it is clear that LDEQ was incorrect in asserting that BACT was not "reevaluated."

PSD-LA-766(M2)
TABLE III. BACT SELECTION

Equipment	$PM_{10}/PM_{2.5}$	NO_x	CO	VOC	GHG
EQT0068 - EQT0073 EQT0094 - EQT0096 Turbines	GCP & FBNG $PM_{10}/PM_{2.5}$ <= 0.0076 lb/MM BTU	DLN & GCP NOx <= 15 ppmvd @ 15% O_2	GCP & FBNG CO <= 15 ppmvd @ 15% O_2	GCP &FBNG VOC <= 1.6 ppmvd @ 15% O_2	GCP & FBNG Use high thermal efficiency turbines
EQT0044 - EQT0046 EQT0049, EQT0050 EQT0087, EQT0088 Water Pumps	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	GCP
EQT0051 - EQT0053 EQT0090 - EQT0092 Generators	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	GCP
EQT0056, EQT0057 EQT0081, EQT0082 Thermal Oxidizers	GED & POP & FBNG	Good equipment designs & proper operating practices (GED & POP)	GED & POP & FBNG Natural gas fuel	GED & POP & FBNG	GED & POP & FBNG
EQT0079, EQT0083 EQT0084 Flares	Proper plant operations and maintaining the presence of the flame at the flare tips when vent gas is routed to the flares				
EQT0077, EQT0080 EQT0097 Condensate Tanks				Closed vent and control devices that meet 40 CFR 60 Subpart Kb	
EQT0078 Condensate Loading				Vapor balanced loading GED & POP	
FUG0002 Fugitives				LAC 33:III.2111	LDAR

LAC 33:III.2111: All rotary pumps and compressors handling volatile organic compounds having a true vapor pressure of 1.5 psia or greater at handling conditions shall be equipped with mechanical seals or other equivalent equipment

PSD-LA-766(M3)

The next modification, PSD-LA-766(M3) was issued on February 17, 2017. It shows the addition of two diesel tanks, which did not change the NOx emissions. From its Briefing Sheet, the NOx emissions from the facility after M3 was the same as after M2, i.e., 3172.23 tons per year, per table below, which shows the M2 values in the "Before" column. However, it is not clear why the "Before" column shows 3172.23 tons per year, when Trains 4 and 5 have not begun construction.

Pollutant	Before	After	Change	PSD De Minimis	PSD Review
$PM_{10}/PM_{2.5}$	438.43	438.43	-	15/10	Yes
SO_2	27.09	27.09	-	40	No
NO_X	3,172.23	3,172.23	-	40	Yes
CO	3,147.26	3,147.26	-	100	Yes
VOC	226.32	226.32	-	40	Yes
CO_2e	9,029,617	9,029,617	-	75000	Yes
Lead	0.002	0.002	-	0.6	No

The BACT Selection Table III from PSD-LA-766(M3) is shown below. They are the same as the M2 listings. No BACT reevaluation was done.

PSD-LA-766(M3)

TABLE III. BACT SELECTION

Equipment	$PM_{10}/PM_{2.5}$	NO_X	CO	VOC	GHG
EQT0068 - EQT0073 EQT0094 - EQT0096 Turbines	GCP & FBNG $PM_{10}/PM_{2.5}$ <= 0.0076 lb/MM BTU	DLN & GCP NOx <= 15 ppmvd @ 15% O_2	GCP & FBNG CO <= 15 ppmvd @ 15% O_2	GCP &FBNG VOC <= 1.6 ppmvd @ 15% O_2	GCP & FBNG Use high thermal efficiency turbines
EQT0044 - EQT0046 EQT0049, EQT0050 EQT0087, EQT0088 Water Pumps	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	GCP
EQT0051 - EQT0053 EQT0090 - EQT0092 Generators	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	GCP
EQT0056, EQT0057 EQT0081, EQT0082 Thermal Oxidizers	GED & POP & FBNG	Good equipment designs & proper operating practices (GED & POP)	GED & POP & FBNG Natural gas fuel	GED & POP & FBNG	GED & POP & FBNG
EQT0079, EQT0083 EQT0084 Flares	Proper plant operations and maintaining the presence of the flame at the flare tips when vent gas is routed to the flares				
EQT0077, EQT0080 EQT0097 Condensate Tanks				Closed vent and control devices that meet 40 CFR 60 Subpart Kb	
EQT0078 Condensate Loading				Vapor balanced loading GED & POP	
EQT0085, EQT0086 Diesel Tanks				Fixed roofs	
FUG0002 Fugitives				LAC 33:III.2111	LDAR

LAC 33:III.2111: All rotary pumps and compressors handling volatile organic compounds having a true vapor pressure of 1.5 psia or greater at handling conditions shall be equipped with mechanical seals or other equivalent equipment

Proposed Permit PSD-LA-766(M4)

That brings us to the current permitting action, i.e., the issuance of proposed PSD-LA-766(M4). First, the table below shows the emissions summary from the Statement of Basis for M4.

Pollutant	Before	After	Change
$PM_{10}/PM_{2.5}$	438.73	438.78	+ 0.05
SO_2	27.11	27.68	+ 0.57
NO_X	3,177.61	3,177.20	- 0.41
CO	3,144.35	3,112.87	- 31.48
VOC	229.40	266.69	+ 37.29
Lead	0.003	0.002	- 0.001

The "Before" value is listed in the table is 3177.61 tons/year for NOx, but it does not match the M3 NOx "After" value of 3172.23 tons/year. The increase of 5.38 tons/year is not discussed or explained anywhere that I could find. Similarly, the "Before" values for the other pollutants are also not the same as the "After" values in the M3 version of the PSD permit, as can be readily verified. Again, no explanation is provided. Note also the expected VOC increase of 37.29 tons/year in the table above from the Statement of Basis for M4, which I have previously discussed.

A few pages later in the permit package, in the Briefing Sheet for M4, however, the following different emissions summary table is provided.

Pollutant	Before	After	Change	PSD De Minimis	PSD Review
$PM_{10}/PM_{2.5}$	403.22	403.31	+ 0.09	15/10	No
NO_X	2,924.55	2,927.04	+ 2.49	40	No
CO	2,895.38	2,865.58	- 29.80	100	No
VOC	195.72	198.07	+ 2.35	40	No
CO_2e	8,478,162	8,478,502	+ 340	75,000	No

Note that all of the "Before" and "After" values are very different and lower than the table in the Statement of Basis for M4 shown above. Neither the Statement of Basis nor the Briefing Sheet (nor the Preliminary Determination Summary, which has the same table as the Briefing Sheet) provide any explanation for providing two very different emission summary tables for the same proposed modification M4.

In addition, the emissions in the "Change" column also do not match, in particular the +37.29 tons/year of VOC increase in the Statement of Basis is reduced to +2.35 in the Briefing Sheet. Again, no explanation is provided. This same table also appears in the Preliminary Determination Summary, i.e., is different from the Statement of Basis, and inconsistent with the prior M3 permit emissions summary.

LDEQ must clarify these unexplained discrepancies in the proposed M4 permit.

The M4 permit's proposed BACT determination is the same, as summarized in the table below.

PSD-LA-766(M4)

TABLE III. BACT SELECTION

Equipment	$PM_{10}/PM_{2.5}$	NO_X	CO	VOC	GHG
EQT0068 - EQT0073 EQT0094 - EQT0096 Turbines	Good combustion practices Fueled by natural gas $PM_{10}/PM_{2.5}$ <= 0.0076 lb/MM BTU	Dry Low NOx burner Good combustion practices NOx <= 15 ppmvd @ 15% O_2	Good combustion practices Fueled by natural gas CO <= 15 ppmvd @ 15% O_2	Good combustion practices Fueled by natural gas VOC <= 1.6 ppmvd @ 15% O_2	Good combustion practices Fueled by natural gas Use high thermal efficiency turbines
EQT0044 - EQT0046 EQT0049 - EQT0053 EQT0087 - EQT0092 Emergency Engines	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	40 CFR 60 Subpart IIII	Good combustion practices
EQT0056, EQT0057 EQT0081, EQT0082 Thermal Oxidizers	Good equipment designs Proper operating practices Fueled by natural gas	Good equipment designs Proper operating practices	Good equipment designs Proper operating practices Fueled by natural gas	Good equipment designs Proper operating practices Fueled by natural gas	Good equipment designs Proper operating practices Fueled by natural gas
EQT0077, EQT0080 EQT0097 Condensate Tanks				Closed vent and control devices that meet 40 CFR 60 Subpart Kb	
EQT0078 Condensate Loading				Vapor balanced loading Good equipment designs Proper operating practices	
EQT0085, EQT0086 Diesel Tanks				Fixed roofs	
FUG0002, FUG0003 Fugitives				LAC 33:III.2111	LDAR
EQT0079, EQT0083 Flares	Proper plant operations and maintaining the presence of the flame at the flare tips when vent gas is routed to the flares				

LAC 33:III.2111: All rotary pumps and compressors handling volatile organic compounds having a true vapor pressure of 1.5 psia or greater at handling conditions shall be equipped with mechanical seals or other equivalent equipment

F. Comment on the BACT Determinations, with the Turbine NOx BACT as Example

It is my view that the LDEQ must revisit the BACT determinations because, as explained below, they are clearly outdated.

I will use NOx from the turbines as an example. As discussed, the original permit, issued in October 2013 determined that BACT is 15 ppm corrected to 15% oxygen. This is identical to the BACT proposed for M4. Assuming permit issuance in the next several months, the turbine NOx BACT has not changed in 8 years, according to LDEQ. In that timeframe, LDEQ has authorized facility NOx emissions increases from a level of 473.88 tons/year to a level of 3177.61 tons/year (per Statement of Basis for M4, as discussed above), an increase of over 2700 tons/year, with just one initial BACT determination.

I note that Cameron's own analysis shows that the surrounding area is clearly modeling in non-attainment. See the summary modeling table below taken from the Briefing Sheet (p.4) accompanying the issuance of the operating permit 0560-00184-V4 on March 3, 2016, i.e., at the time of issuance of the PSD-LA-766(M2) permit,[8] the last time any modeling was done, when the NOx emissions was 3172.73 tons/year, which is close but lower than the proposed NOx level of 3177.20 tons/year.

VII. Effects on Ambient Air

Dispersion Model Used: AERMOD - May 2013

Pollutant	Averaging Period	Calculated Maximum Ground Level Concentration ($\mu g/m^3$)	NAAQS or AAS ($\mu g/m^3$)
$PM_{2.5}$	24 hour	0.99	35
	Annual	0.05	12
Nitrogen Dioxide	1 hour	(Refined) (*) 3,113	188
	Annual	0.86	100
Carbon Monoxide	1 hour	109.15	40,000
	8 hour	45.33	10,000

(*)Project's maximum contribution to an exceedance of the NAAQS is 3.68 $\mu g/m^3$. Project's maximum contribution to the maximum concentration of 3,113 $\mu g/m^3$ is 0.00014 $\mu g/m^3$.

To reiterate, the modeling by Cameron clearly shows that the maximum 1-hour NOx in the area was 3113 micrograms per cubic meter, which is over 16 times the 1-hour NOx NAAQS of 188 micrograms per cubic meter. Even though the facility's contribution may have been determined to be relatively small (i.e., 3.68 micrograms per cubic meter as shown in the note below the table above) – and I disagree that it is that small and therefore smaller than the interim SIL value of 7.5 micrograms per cubic meter, given the underestimation of potential-to-emit NOx estimates from many sources using questionable emissions factors from AP-42 which I discuss next – nonetheless, it is clear that the area surrounding Cameron is non-attainment for the 1-hour NOx NAAQS.

Therefore the proper New Source Level analysis should be focused on LAER and not NOx. It is clear from even a review of the EPA's RBLC database that there are substantially lower NOx BACT and LAER determinations for the turbines. While a proper LAER/BACT analysis should include a thorough review of the current state-of-the-art in turbine NOx emissions and not just be

[8] This confirms that the modeling was done in May 2013.

limited to RBLC review, the fact that even the RBLC contains much more stringent NOx determinations is indicative that the 15 ppm at 15% oxygen NOx BACT from the turbines is not current LAER or even BACT.

I show below the RBLC summary for Robinson Power Company LLC's gas powered turbine, without duct burners, for which the NOx LAER determinations is 2 ppm. The permit was issued on December 27, 2017.

RBLC ID: PA-0314
Corporate/Company: ROBINSON POWER COMPANY, LCC
Facility Name: BEECH HOLLOW
Process: COMBUSTION TURBINE without DUCT BURNERS UNIT

Primary Fuel: Natural Gas
Throughput: 2433.00 MMBtu/hr
Process Code: 16.110

Pollutant Information - List of Pollutants

Help

Pollutant	Primary Emission Limit	Basis	Verified
Carbon Dioxide Equivalent (CO2e)	404917.0000 LB		UNKNOWN
Carbon Monoxide	2.0000 PPDV	BACT-PSD	UNKNOWN
Hydrochloric Acid	1.0500 LB	BACT-PSD	UNKNOWN
Nitrogen Oxides (NOx)	2.0000 PPMDV	LAER	UNKNOWN
Particulate matter, filterable (FPM)	18.2000 LB	BACT-PSD	UNKNOWN
Particulate matter, filterable < 10 µ (FPM10)	18.2000 LB	BACT-PSD	UNKNOWN
Particulate matter, filterable < 2.5 µ (FPM2.5)	18.2000 LB	BACT-PSD	UNKNOWN
Volatile Organic Compounds (VOC)	1.3000 PPMDV	LAER	UNKNOWN

Process Notes: CEMS for NOx, CO

In addition, I also show a BACT determination for the Guadalupe Generating Station below, which was issued on October 4, 2013 (i.e., fairly close in time to the initial PSD-LA-766 permit for Cameron), showing NOx BACT from the turbine of 9 ppm.

RBLC ID: TX-0685
Corporate/Company: GUADALUPE POWER PARTNERS LP
Facility Name: GUADALUPE GENERATING STATION
Process: (2) simple cycle turbines

Primary Fuel: natural gas
Throughput: 190.00 MW
Process Code: 16.110

Pollutant Information - List of Pollutants

Help

Pollutant	Primary Emission Limit	Basis	Verified
Carbon Monoxide	9.0000 PPMVD	BACT-PSD	UNKNOWN
Nitrogen Oxides (NOx)	9.0000 PPMVD	BACT-PSD	UNKNOWN
Particulate matter, total < 2.5 µ (TPM2.5)	0	BACT-PSD	UNKNOWN

Process Notes: Four models are approved: GE7FA.03, GE7FA.04, GE7FA.05, or Siemens SW 5000F5. 383 MW to 454 MW total plant capacity.

Based on this, it is clear that DEQ's lack of review of BACT, even after 8 years since the last review, while authorizing NOx emissions increases of over 2700 tons per year into a NOx non-attainment area is improper. Any current BACT for NOx for the turbines would result in lower BACT than the 15 ppm at 15% oxygen BACT determination from 2013.

G. Use of Inappropriate and Other Unsupported Assumptions in the Emissions Calculations

Next I show examples emissions calculations focusing on three aspects. First, the use of an emission factor for NOx from the flares of 0.068 lb/MMBtu is inappropriate. Second, the use of a particularly aggressive and unsupported assumption of 99.5% destruction efficiency of VOCs from flares and other devices is unsupported. And third, the use of AP-42 in many of the emissions calculations is unsupported and inappropriate. I discuss each of these assumptions in the subsequent sections following this one and show why they are inappropriate and why the 99.5% VOC destruction assumption and the flare NOx emission factor serve to artificially suppress the PTE emissions of these pollutants from Cameron. But, before I do so, in the next section, I provide some examples of the use of these assumptions in the emissions calculations using excerpts from the permit Application and Addenda.

1. Examples of Unsupported Assumptions

As an initial matter, I note that these are meant to be examples only and this section does not purport to provide an exhaustive listing of every instance in which one or more of the three assumption listed above, are used. I have highlighted, using red boxes, the various assumptions.

I begin with the calculations submitted with the March 19, 2021 Addendum.

(i) The excerpted table below shows the use of AP-42 in estimating TAP emissions at the turbines.

CAMERON LNG, LLC
CAMERON LNG Hackberry, LA Facility
EU15D/E/F/G/I, Refrigeration Compressor Turbines (PR)

Hazardous/Toxic Air Pollutants (HAPs/TAPs)		See Note 3	Average lbs/hr	Maximum lbs/hr	Annual TPY	Calculation Methodology (lbs/hr)
1,3-Butadiene	4.30E-07	lbs/MMBtu	< 0.001	0.001	0.004	[illegible]
Acetaldehyde	4.00E-05	lbs/MMBtu	0.04	0.05	0.19	[illegible]
Acrolein	6.40E-06	lbs/MMBtu	0.01	0.01	0.03	[illegible]
Benzene	1.30E-05	lbs/MMBtu	0.01	0.02	0.06	[illegible]
Ethylbenzene	3.20E-05	lbs/MMBtu	0.03	0.04	0.15	[illegible]
Formaldehyde	7.10E-04	lbs/MMBtu	0.76	0.91	3.32	[illegible]
Naphthalene	1.30E-06	lbs/MMBtu	0.001	0.002	0.01	[illegible]
PAH	2.20E-06	lbs/MMBtu	0.002	0.003	0.01	[illegible]
Propylene Oxide	2.90E-05	lbs/MMBtu	0.03	0.04	0.14	[illegible]
Toluene	1.30E-04	lbs/MMBtu	0.14	0.17	0.61	[illegible]
Xylene	6.40E-05	lbs/MMBtu	0.07	0.08	0.30	[illegible]
Sulfuric Acid Mist (H_2SO_4) [4]	1.85E-01	lbs/hr	0.01	0.02	0.06	[illegible]

CO2e	Mass Flow (lbs/hr)	Lbs/MMBtu	544,550	Annual TPY	Emission Factor References
Carbon Dioxide	124,314	------	544,495	TPY	Engineering estimate
Methane		0.0086	40	[illegible]	AP 42, Chapter 3, Table 3.1-2a
Nitrous Oxide		0.003	14	[illegible]	AP 42, Chapter 3, Table 3.1-2a

1 Emission factors are based on vendor data.
2 A safety factor of 1.2 is used to calculate maximum emissions for all pollutants except for NOx which uses a safety factor of 1.02.
3 HAP/TAP emission factors (except N2O) are based on EPA AP-42, Section 3.1, Table 3.1-3, Emission Factors.
4 Assumes 5% of the sulfur in the fuel is converted to SO_3 and 100% will react with water vapor to form sulfuric acid mist.

(ii) Next, from Cameron's April 27, 2021 Title V Renewal Application - Permit Application Addendum, I have excerpted several (but not all) flare emissions calculations, highlighting the use of AP-42, the 99.5% VOC destruction efficiency, and the flare NOx emission factor of 0.068 lb/MMBtu.

Source Description:
EU20, Ground Flare

HP Dry Flare Line

Operating Schedule: 8,760 HPY
Heat Input: 42.0 MMBtu/hr

Pollutant	Emission Factor	Unit of Measurement	lb/hr	TPY	Factor Source
CO	0.31	lb/MMBtu	13.02	57.03	AP-42, Tables 13.5-2 (02/18)
NO_x	0.068	lb/MMBtu	2.86	12.51	AP-42, Tables 13.5-1 (02/18)
PM_{10}	0.0075	lb/MMBtu	0.31	1.37	AP-42, Tables 1.4-2 (07/98)
$PM_{2.5}$	0.0075	lb/MMBtu	0.31	1.37	AP-42, Tables 1.4-2 (07/98)
SO_2	NA	lb/MMBtu	0.026	0.114	3 ppmw H_2S and 1 ppm of organic sulfur in pipeline gas
VOC (from combustion)	0.0054	lb/MMBtu	0.23	0.99	AP-42, Tables 1.4-2 (07/98)
GHGs (CO_2e)			5,209	**22,817**	
Methane	based on 98.5% efficiency of CH4		7.47	32.70	NA
CO_2	NA	mol/mol fuel	5020	21,988	material balance
N_2O	0.00022	lb/MMBtu	0.0092	0.04	40 CFR 98, Subpart C Table C-2

DRE - VOC Determination

	lbmol/hr	DRE	lbmol/hr	lb/hr	TPY
Total VOC	6.222	99.5%	0.0311	0.83	3.66
TAPs/HAPs					
n-Hexane	0.235	99.5%	0.0012	0.10	0.44

HP Wet Flare Line

Operating Schedule: 8,760 HPY
Heat Input: 29.0 MMBtu/hr

Pollutant	Emission Factor	Unit of Measurement	lb/hr	TPY	Factor Source
CO	0.31	lb/MMBtu	8.99	39.38	AP-42, Tables 13.5-2 (02/18)
NO_x	0.068	lb/MMBtu	1.97	8.64	AP-42, Tables 13.5-1 (02/18)
PM_{10}	0.0075	lb/MMBtu	0.22	0.95	AP-42, Tables 1.4-2 (07/98)
$PM_{2.5}$	0.0075	lb/MMBtu	0.22	0.95	AP-42, Tables 1.4-2 (07/98)
SO_2	NA	lb/MMBtu	0.018	0.079	3 ppmw H_2S and 1 ppm of organic sulfur in pipeline gas
$VOC_{(from\ combustion)}$	0.0054	lb/MMBtu	0.16	0.68	AP-42, Tables 1.4-2 (07/98)
GHGs (CO_2e)			3,546	15,532	
Methane	based on 99.5% efficiency of CH4		3.100	13.58	NA
CO_2	NA	mol/mol fuel	3467	15,184	material balance
N_2O	0.00022	lb/MMBtu	0.0064	0.03	40 CFR 98, Subpart C Table C-2

DRE - VOC Determination

	lbmol/hr	DRE	lbmol/hr	lb/hr	TPY
Total VOC	2.1442	99.5%	0.01	0.58	2.52
TAPs/HAPs					
n-Hexane	0.1617	99.5%	0.0008	0.07	0.31

LP Wet Flare Line

Operating Schedule: 8,760 HPY
Total MMBtu/hr 2.33 MMBtu/hr

Pollutant	Emission Factor	Unit of Measurement	lb/hr	TPY	Factor Source
CO	0.31	lb/MMBtu	0.72	3.17	AP-42, Tables 13.5-2 (02/18)
NO_2	0.068	lb/MMBtu	0.16	0.69	AP-42, Tables 13.5-1 (02/18)
PM_{10}	0.0075	lb/MMBtu	0.02	0.08	AP-42, Tables 1.4-2 (07/98)
$PM_{2.5}$	0.0075	lb/MMBtu	0.02	0.08	AP-42, Tables 1.4-2 (07/98)
SO_2	NA	lb/MMBtu	0.00136	0.0059	3 ppmv H_2S and 1 ppm of organic sulfur in pipeline gas
$VOC_{from\ combustion}$	0.0054	lb/MMBtu	0.013	0.06	AP-42, Tables 1.4-2 (07/98)
GHGs (CO_2e)			277	1,212	
Methane	based on 99.5% efficiency of CH4		0.40	1.75	NA
CO_2	NA	mol/mol fuel	267	1168	material balance
N_2O	0.00022	lb/MMBtu	0.000513	0.002	40 CFR 98, Subpart C Table C-2

DRE - VOC Determination

	lbmol/hr	DRE	lbmol/hr	lb/hr	TPY
Total VOC	0.1617	99.5%	0.0008	0.043	0.19
TAPs/HAPs					
n-Hexane	0.0122	99.5%	0.00006	0.0053	0.02

LP Dry Flare Line

Operating Schedule: 8,760 HPY
Heat Input: 17.67 MMBtu/hr

Pollutant	Emission Factor	Unit of Measurement	lb/hr	TPY	Factor Source
CO	0.31	lb/MMBtu	5.48	23.99	AP-42, Tables 13.5-2 (02/18)
NO_x	0.068	lb/MMBtu	1.20	5.26	AP-42, Tables 13.5-1 (02/18)
PM_{10}	0.0075	lb/MMBtu	0.13	0.58	AP-42, Tables 1.4-2 (07/98)
$PM_{2.5}$	0.0075	lb/MMBtu	0.13	0.58	AP-42, Tables 1.4-2 (07/98)
SO_2	NA	lb/MMBtu	0.010	0.04	3 ppmv H_2S and 1 ppm of organic sulfur in pipeline gas
$VOC_{(non-combustion)}$	0.0054	lb/MMBtu	0.10	0.42	AP-42, Tables 1.4-2 (07/98)
GHGs (CO_2e)			2,184	9,568	
Methane	based on 99.5% efficiency of OH		2.800	12.264	NA
CO_2	NA	mol/mol fuel	2113	9256	material balance
N_2O	0.00022	lb/MMBtu	0.003887	0.02	40 CFR 98, Subpart C Table C-2

DRE - VOC Determination

	lbmol/hr	DRE	lbmol/hr	lb/hr	TPY
Total VOC	2.4369	99.5%	0.01	0.60	2.61
TAPs/HAPs					
n-Hexane	0.0461	99.5%	0.0002	0.020	0.09

(iii) Next, I show another calculation in Cameron's April 27, 2021 Title V Renewal Application - Permit Application Addendum showing the use of the 99.5% destruction efficiency and the flare NOx emission factor.

n-Hexane flow to Control Device

Number of cleaning activities/yr [1]	6	
Chemical usage for cleaning [1,2]	25,000.00	gallons
Heat content [3]	19,246.00	Btu/lb
Specific gravity [3]	0.659	
Density [3]	5.5	lb/gal
Duration/activity [1]	960	hrs
Flow routed to control (n-Hexane)/activity	137,483.88	lbs
Flare used for control	EU20 - Ground Flare (EQT0079)	
Flare destruction efficiency [6]	99.5	%

Emissions

Pollutant		Emission Factor	Unit	lb/hr	tons/yr
CO	[6]	0.31	lb/MM Btu	0.85	2.46
NOx	[6]	0.068	lb/MM Btu	0.19	0.54
PM-10	[6]	0.0075	lb/MM Btu	0.02	0.06
PM-2.5	[6]	0.0075	lb/MMBtu	0.02	0.06
SO2	[7]	NA		0.01	0.04
VOC	[7]	NA		0.72	2.06
GHGs (CO2e)	[8]				1,037
CO2	[8]	99	kg/MM Btu		1,033
Methane	[8]	0.003	kg/MMBtu		0.03
N2O	[8]	6.00E-04	kg/MMBtu		0.011
Toxic Air Pollutants					
n-Hexane	[7]	NA		0.72	2.06
Benzene	[7]	NA		7.16E-07	2.06E-06

Notes

1. Based on cleaning chemical specification provided by John Wainwright (Cameron) to Valerie Kazlauskas (Trinity) on 4/7/21.
2. Number of activities provided by John Wainwright (Cameron) to Valerie Kazlauskas (Trinity) on 4/9/21.
3. Estimated chemical usage provided by Scott Mills (Cameron) to Valerie Kazlauskas (Trinity) on 4/9/21.
4. Assumed a contingency of 25% for the total n-Hexane usage per activity.
5. Properties of n-Hexane obtained from "https://cameochemicals.noaa.gov/chris/HXA.pdf".
6. Flare destruction removal efficiency and emission factors are based on Title V renewal application submitted on September 2, 2020.
7. VOC, TAP and SO2 emissions are estimated based on actual composition of the material routed to flare and flare DRE.
8. Greenhouse gas emissions are estimated using the emission factors for fuel gas (n-Hexane) from Tables C-1 and C-2 to Subpart C of 40 CFR 98.

(iv) In the September 2, 2020 renewal application at pages B-13 to B-32 and also B-44 to B-55, Cameron's consultants show VOC emissions from tanks. All were performed relying on AP-42, Section 7.1.3.1. I did not excerpt these tables because of their size and legibility.

(v) In the September 2, 2020 application, starting at page C-1 (EU01A) through page C-11 (EU01J), are shown the calculations for the identical Submerged Combustion Vaporizers. The sum of all of the vaporizers is shown as EU06-CAP on page C-12. The excerpt for EU01A is shown below:

Source I.D.: Submerged Combustion Vaporizer
Source ID No. EU01A; EQT0001
Source is Capped under EU08-CAP Vaporizers

Operating Hours per Year:	8760
Heat Rate (MMBtu/hr):	120

Pollutant	Emission Factor	Unit of Measurement	Max lb/hr	Factor Source
PM_{10}	0.0075	lb/MMBtu	0.89	AP-42, Tables 1.4-2 (07/98)
$PM_{2.5}$	0.0075	lb/MMBtu	0.89	AP-42, Tables 1.4-2 (07/98)
SO_2 (1)	0.0007	lb/MMBtu	0.08	AP-42, Tables 1.4-2 (07/98)
NO_x	0.051	lb/MMBtu	13.23	See Note 4
CO	0.036	lb/MMBtu	30.86	See Note 4
VOC	0.0054	lb/MMBtu	0.65	AP-42, Tables 1.4-2 (07/98)
Hazardous/Toxic Air Pollutants (HAPs/TAPs)			0.0097	
Benzene	0.0000021	lb/MMBtu	0.0002	AP-42, Tables 1.4-3 (07/98)
Formaldehyde	0.000074	lb/MMBtu	0.009	AP-42, Tables 1.4-3 (07/98)
Lead Compounds	0.0000005	lb/MMBtu	0.0001	AP-42, Tables 1.4-2 (07/98)
n-Hexane	0.0000013	lb/MMBtu	0.0002	AB 2588 Combustion Emission Factors
Toluene	0.0000033	lb/MMBtu	0.0004	AP-42, Tables 1.4-3 (07/98)
GHGs (CO_2e)			14,051.30	
Methane	0.0023	lb/mmBTU	0.27	AP-42, Tables 1.4-2 (07/98)
N_2O	0.0001	kg N2O/MMBtu	0.03	40 CFR 98, Subpart C Table C-2
CO_2	53.06	kg CO2/MMBtu	14,037.26	40 CFR 98, Subpart C Table C-1

Notes:
(1) SO_2 emissions are based on a sulfur content of 0.5 grains/100 scf.
(2) n-Hexane emission factor based on "AB 2588 Combustion Emission Factors", Ventura County Air Pollution Control District, Ventura Co., May 17, 2001.
(3) There is no published emission factor for emissions of $PM_{2.5}$. As a conservative measure, $PM_{2.5}$ emissions are assumed to be 100% of PM_{10} emissions.
(4) NOx and CO factors are based on startup conditions of 80 ppmv for NOx and 300 ppmv for CO.

In addition to the extensive and unsupported use of AP-42, I also note two other unsupported assumptions—namely the use of AB2588 Combustion Emission Factors from Ventura County in California just for the hexane calculations, apparently because AB2588 has a smaller emission factor than AP-42. And the NOx and CO factors at startup, i.e., 80 ppmv and 300 ppmv, respectively in Note (4), have no stated basis whatsoever.

(vi) In the September 2020 Application, at page C-13, Cameron includes calculations for the fuel gas heater, excerpted below. Note the use of AP-42 factors and also the reference to "vendor information." Again, the use of AP-42 factors is inappropriate. Moreover, there is no vendor information provided in the application, and therefore the calculations are unsupported.

Source I.D.: Fuel Gas Heater
Source ID No. EU03A; EQT0016
Source is Capped under EU03-CAP Fuel Gas Heaters Cap

Operating Hours per Year:	8,760
Heat Rate (MMBtu/hr):	3.6

Pollutant	Emission Factor	Unit of Measurement	Max lb/hr	TPY	Factor Source
PM_{10}	0.0075	lb/MMBtu	0.03	0.12	AP-42, Tables 1.4-2 (07/98)
$PM_{2.5}$	0.0075	lb/MMBtu	0.03	0.12	AP-42, Tables 1.4-2 (07/98)
SO_2 (1)	0.0007	lb/MMBtu	0.003	0.01	AP-42, Tables 1.4-2 (07/98)
NO_x	0.084	lb/MMBtu	0.32	1.40	Vendor Information
CO	0.053	lb/MMBtu	0.20	0.88	Vendor Information
VOC	0.0054	lb/MMBtu	0.02	0.09	AP-42, Tables 1.4-2 (07/98)
Hazardous/Toxic Air Pollutants (HAPs/TAPs)			0.0003	0.0013	
Benzene	0.0000021	lb/MMBtu	0.00001	0.00003	AP-42, Tables 1.4-3 (07/98)
Formaldehyde	0.000074	lb/MMBtu	0.0003	0.001	AP-42, Tables 1.4-3 (07/98)
Lead Compounds	0.0000005	lb/MMBtu	0.000002	0.00001	AP-42, Tables 1.4-2 (07/98)
n-Hexane	0.0000013	lb/MMBtu	0.000005	0.00002	AP-2588 Combustion Emission Factors
Toluene	0.0000033	lb/MMBtu	0.00001	0.0001	AP-42, Tables 1.4-3 (07/98)
GHGs (CO_2e)			444.98	1949.00	
Methane	0.0023	lb/mmBTU	0.01	0.04	AP-42, Tables 1.4-2 (07/98)
N_2O	0.0001	kg N2O/MMBtu	0.001	0.004	40 CFR 98, Subpart C Table C-2
CO_2	53.06	kg CO2/MMBtu	444.51	1,946.97	40 CFR 98, Subpart C Table C-1

(vii) Continuing with the September 2020 Application, at pages C-14, it discusses emissions from "Flare, Purge and Pilot" excerpted below.

Source I.D.: Flare
Source ID No. EU04; EQT0017

Operating Hours per Year:	8,760
Heat Rate (BTU/scf):	1,145
Purge Gas (SCFH)	3874.24
3 Pilots	360
Total SCFH	4234
Total MMBtu/hr	4.84

Purge and Pilot Emissions

Pollutant	Emission Factor	Unit of Measurement	lb/hr	TPY	Factor Source
CO	0.31	lb/MMBtu	1.532	6.71	AP-42, Tables 13.5-2 (02/18)
NO_x	0.068	lb/MMBtu	0.336	1.47	AP-42, Tables 13.5-1 (02/18)
PM_{10}	0.0075	lb/MMBtu	0.037	0.16	AP-42, Tables 1.4-2 (07/98)
$PM_{2.5}$	0.0075	lb/MMBtu	0.037	0.16	AP-42, Tables 1.4-2 (07/98)
SO_2	0.0006	lb/MMBtu	0.003	0.01	AP-42, Tables 1.4-2 (07/98)
VOC	0.0054	lb/MMBtu	0.027	0.12	AP-42, Tables 1.4-2 (07/98)
Hazardous/Toxic Air Pollutants (HAPs/TAPs)			0.009	0.038	
n-Hexane	0.002	lb/MMBtu	0.009	0.038	AP-42, Tables 1.4-3 (07/98)
GHGs (CO_2e)			585	2,561	
Methane	0.0023	lb/MMBtu	0.011	0.05	AP-42, Tables 1.4-2 (07/98)
N_2O	0.0022	lb/MMBtu	0.011	0.05	AP-42, Tables 1.4-2 (07/98)
CO_2	117.65	lb/MMBtu	581	2,546	AP-42, Tables 1.4-2 (07/98)

Operating Hours per Year:	324
Heat Rate (BTU/scf):	1,020
Purge Gas from Bog (SCFH)	1065,555.56

Note the extensive use of AP-42, including the flare NOx emission factor of 0.068 lb/MMBtu.

(viii) Pages C-27 and C-28 in the September 2020 Application show emissions for the turbines. Also, on pages C-29 and C-30.

EU15A/B/C/G/H, Refrigeration Compressor Turbines (Mixed Refrigerants)

SOURCE DESCRIPTION

Three Mixed Refrigerant Compressor Turbines for Trains 1/2/3. Two additional Mixed Refrigerant Compressor Turbines for Trains 4/5.

OPERATING PARAMETERS

Operating Schedule	8,760	Hrs/yr/turbine
Heat Input	964	MMBtu/hr (LHV)
	1,059	MMBtu/hr (Max Design)
Fuel	Natural Gas	
Exhaust Gas Flow Rate	80,343	lb-mole/ hr (per unit (dry))

EMISSION UNITS

TEMPO

ID	Equipment ID No./Description
EQT068	EU15A, Refrigeration Compressor Turbine (MR)
EQT069	EU15B, Refrigeration Compressor Turbine (MR)
EQT070	EU15C, Refrigeration Compressor Turbine (MR)
EQT093	EU15G Refrigeration Compressor Turbine (MR)
EQT094	EU15H Refrigeration Compressor Turbine (MR)

EMISSION CALCULATIONS

Pollutant	See Note 1	Molecular Weight	Average Lbs/Hr	Maximum[2] Lbs/Hr	Annual TPY	Calculation Methodology (lbs/hr)
Particulate Matter 10	0.008		8.55	10.26	37.46	0.008 lbs PM/MMBtu * 1069 MMBtu/hr
Particulate Matter 2.5	0.008		8.55	10.26	37.46	0.008 lbs PM/MMBtu * 1069 MMBtu/hr
Sulfur Dioxide	0.036	64.07	0.19	0.22	0.81	0.036 ppmv/1,000,000 * 80,343 lb-mole/hr * 64.07 MW
Nitrogen Oxides	15.81	46.0	58.44	69.00	255.98	15.81 ppmv/1,000,000 * 80,343 lb-mole/hr * 46.01 MW
Carbon Monoxide	15.81	28.01	35.58	42.69	155.84	15.81 ppmv/1,000,000 * 80,343 lb-mole/hr * 28.01 MW
VOC	1.6	13.55	2.00	2.40	8.76	1.6 ppmv/1,000,000 * 80,343 lb-mole/hr * 13.55 MW

EU15A/B/C/G/H, Refrigeration Compressor Turbines (Mixed Refrigerants)

Hazardous/Toxic Air Pollutants (HAPs/TAPs)		See Note 3	Average Lbs/Hr	Maximum Lbs/Hr	Annual TPY	Calculation Methodology (lbs/hr)
1,3-Butadiene	4.30E-07	lbs/MMBtu	< 0.001	<0.001	0.004	0.000000430 lbs/MMBtu * 1069 MMBtu/hr
Acetaldehyde	4.00E-05	lbs/MMBtu	0.04	0.05	0.19	0.000004 lbs/MMBtu * 1069 MMBtu/hr
Acrolein	6.40E-06	lbs/MMBtu	0.01	0.01	0.03	0.0000064 lbs/MMBtu * 1069 MMBtu/hr
Benzene	1.20E-05	lbs/MMBtu	0.01	0.02	0.06	0.0000012 lbs/MMBtu * 1069 MMBtu/hr
Ethylbenzene	3.20E-05	lbs/MMBtu	0.03	0.04	0.15	0.0000032 lbs/MMBtu * 1069 MMBtu/hr
Formaldehyde	7.10E-04	lbs/MMBtu	0.76	0.91	3.32	0.00071 lbs/MMBtu * 1069 MMBtu/hr
Naphthalene	1.30E-06	lbs/MMBtu	0.001	0.002	0.01	0.0000013 lbs/MMBtu * 1069 MMBtu/hr
PAH	2.20E-06	lbs/MMBtu	0.002	0.003	0.01	0.0000022 lbs/MMBtu * 1069 MMBtu/hr
Propylene Oxide	2.90E-05	lbs/MMBtu	0.03	0.04	0.14	0.0000029 lbs/MMBtu * 1069 MMBtu/hr
Toluene	1.30E-04	lbs/MMBtu	0.14	0.17	0.61	0.00013 lbs/MMBtu * 1069 MMBtu/hr
Xylene	6.40E-05	lbs/MMBtu	0.07	0.08	0.30	0.0000064 lbs/MMBtu * 1069 MMBtu/hr
Sulfuric Acid Mist (H_2SO_4)[4]	1.59E-01	Lbs/hr	0.01	0.02	0.06	0.159 lbs/hr * 98 lbs H2SO4/lbmole * 5% * 1 lb mole SO2/64 lbs SO2
CO2e	Mass Flow (lbs/hr)	Lbs/MMBtu	544,550	Annual TPY		Emission Factor References
Carbon Dioxide	124,314	-------	544,695	TPY		Engineering estimate
Methane		0.0036	40	80000 lbs/MMBtu * 1069 MMBtu/hr		AP 42, Chapter 3, Table 3.2-1a
Nitrous Oxide		0.0030	34			AP 42, Chapter 3, Table 3.2-1a

REFERENCES/NOTES

1 Emission factors are based on vendor data.

2 A safety factor of 1.2 is used to calculate maximum emissions for all pollutants except for NOx which uses a safety factor of 1.32.

3 HAP/TAP emission factors (except H_2SO_4) are based on EPA AP-42, Section 3.1, Table 3.1-3, Emission Factors.

4 Assumes 5% of the sulfur in the fuel is converted to SO3 and 100% will react with water vapor to form Sulfuric Acid (H_2SO_4) Mist.

Note the extensive use of AP-42. Also note the reference to vendor data which is simply missing in the application. For example, the NOx emission calculation relies on vendor data.

(ix) In the September 2020 application, the emissions calculation from thermal oxidizers are provided in page C-31 and excerpted below.

Thermal Oxidizers Capped: TOCAP

EU13A,EU13B,EU13C,EU13D

The thermal oxidizers will control various process vents, including the condensate storage tanks (EQT0077, EQT0080, and EQT0097) and the amine units (EQT0098-EQT0102).

Operating Schedule:	8,760	hours per year
Total Heat Input to Firebox:	171.17	(MMBtu/hr)
Acid Gas	219.25	(MMBtu/hr)
C5+ Vent	103.12	(MMBtu/hr)
Fuel Gas	68.05	(MMBtu/hr)

Combustion

Pollutant	Emission Factor	Unit of Measurement	lbs/hr	TPY	Factor Source
Carbon Monoxide	0.0820	lbs/MMBtu	14.036	61.48	AP-42, Table 1.4-1 (7/98)
Nitrogen Oxides	0.1000	lbs/MMBtu	17.117	74.97	AP-42, Table 1.4-1(7/98)
Sulfur Dioxide	NA	lbs/MMBtu	3.268	14.313	5 ppmv H_2S in fuel gas, 3ppm of H2S and 1 ppm organic sulfur in acid gas
PM10	0.0075	lbs/MMBtu	1.284	5.62	AP-42, Tables 1.4-2 (7/98)
PM2.5[1,2]	0.0075	lbs/MMBtu	1.284	5.62	AP-42, Tables 1.4-2 (7/98)
VOC (from combustion)	0.0054	lbs/MMBtu	0.924	4.05	AP-42, Tables 1.4-2 (7/98)
GHGs (CO_2e)			570,417	**2,498,425**	
Methane	0.001	kg CH_4/MMBtu	0.861	3.77	40 CFR 98, Subpart C Table C-1
CO_2	32960	lbmol/hr	570370	2498219	stoichiometry
N_2O	0.0001	kg N_2O/MMBtu	0.086	0.377	40 CFR 98, Subpart C Table C-1

Note:

There is no published emission factor for emissions of PM2.5. As a conservative measure, PM2.5 emissions are assumed to be 100% of PM10 emissions.

DRE - VOC Determination

C5+ and Acid Gas Streams	lbmol/hr		DRE		lbmol/hr	lb/hr	TPY
Total VOC	57.30		99.5%		0.29	21.27	52.87
TAPs/HAPs							
Benzene	1.75		99.5%		0.0088	0.68	1.57
n-Hexane	6.01		99.5%		0.0301	2.59	6.07

Note:

Tons per year for emissions attributed to thermal expansion based on highest thermal expansion rate in 12hr period since this will occur only during day time by solar insolation.

Note again, the reliance on both AP-42 and the 99.5% destruction efficiency.

(x) Finally, as the last example, the flare SSM calculations are shown in the September 2020 Application at pages C-37 through C-39. I am not excerpting these tables because they are illegible in the original version available to the public. Nonetheless, as I have noted earlier, they contain numerous assumptions. And a review of the proposed PSD(M4) permit or the title V permit shows no verification of these many assumptions at all.

It is also not clear if or how any of these SSM emissions were modeled since they were created after the May 2013 modeling.

2. The Flare NOx Emission Factor

As discussed, the emissions calculations for NOx from the flares rely exclusively on the 0.068 lb/MMBtu emission factor, from AP-42, Table 13.5-1.[9] I reproduce this table from AP-42 below, omitting all notes but including the crucial note [b] qualifying the 0.068 lb/MMBtu emission factor.

Table 13.5-1 (English Units). THC, NOx AND SOOT EMISSIONS FACTORS FOR FLARE OPERATIONS FOR CERTAIN CHEMICAL MANUFACTURING PROCESSES[a]

Pollutant	SCC[c]	Emissions Factor Value	Emissions Factor Units	Grade or Representativeness
THC, elevated flares[e]	30190099; 30119701; 30119705; 30119709; 30119741	0.14[b,f]	lb/10^6 Btu	B
THC, enclosed ground flares[g,h] Low Percent Load[i]		8.37[j] or 3.88e-3[f]	lb/10^6 scf gas burned lb/10^6 Btu heat input	Moderately
THC, enclosed ground flares[g,h] Normal to High Percent Load[i]		2.56[j] or 1.20e-3[f]	lb/10^6 scf gas burned lb/10^6 Btu heat input	Moderately
Nitrogen oxides, elevated flares[d]		0.068[b,k]	lb/10^6 Btu	B
Soot, elevated flares[d]		0 – 274[b]	µg/L	B

b Reference 1. Based on tests using crude propylene containing 80% propylene and 20% propane.

The 0.068 lb/MMBtu value in AP-42 above is derived from testing discussed in Reference 1 in that section of AP-42, a 1983 document which discusses a range of flare NOx emissions, as high as 0.2 lb/MMBtu (or three times as high as the "average" 0.068 lb/MMBtu in the table below). Importantly, all of the flare testing data upon which the 0.068 lb/MMBtu NOx emission factor in AP-42 is based were developed out of testing conducted on an idealized propylene-only flare – contrary to what is stated in FN a to the table above (i.e., "80% propylene and 20% propane." A review of Reference 1 in FN a to the AP-42 Table 13.5-1 makes that clear.

In this instance, nothing in the permitting materials including the permit application and addenda indicates that any of the flares will burn just 100% propylene, like the flare that is the basis of AP-42's NOx emission factor. Thus, LDEQ's reliance on that the emission factor is fundamentally unsupported.

Further, as noted, the underlying AP-42 background document clearly states that there is a range of NOx emission factors, with the highest being 0.2 lb/MMBtu instead of the average value of 0.068 lb/MMBtu. Consistent with the definition of PTE, at the very least, this highest value should be used to estimate PTE unless better quality site-specific data representing all flaring conditions can be developed. Doing so would increase the annual NOx PTE from the flare, including SSM emissions, by a factor of roughly 3 times.

[9] https://www3.epa.gov/ttn/chief/ap42/ch13/final/C13S05_02-05-18.pdf

This has important implications because, as the May 2013 modeling for NOx showed, Cameron's contribution was 3.68 micrograms per cubic meter, which was less than the interim SIL value of 7.5 micrograms per cubic meter. If the flare NOx emissions are so dramatically underestimated, it is likely that this contribution would be much greater than 3.68 micrograms per cubic meter, and potentially greater than the SIL.

3. VOC Destruction Efficiency at the Flare

As noted in the emissions calculation examples, Cameron has uniformly, and without any support, used a value of destruction efficiency of 99.5% from the flares and other combustion equipment. As I note later, there are no permit conditions requiring verification of this destruction efficiency and there should be.

It is well known that flare destruction efficiency depends on many factors which cannot be controlled in actual operating conditions. These include but are not limited to: the volume of waste gases; the composition of waste gases; the type of burner in the flare; the ambient conditions; which affect the heat losses and therefore the temperature profile of the flare; and many others. Therefore, it is simply not credible to assume, without continuous verification, that this level of destruction efficiency is valid under all conditions.

And the implications of being wrong on the emissions is dramatic. For example, if 100 pounds of VOCs are measured going into the flare, i.e., the inlet mass, then a 99.5% destruction means that 0.5 pounds of VOCs are emitted. Consider what happens if the destruction efficiency drops even slightly to just 99%, a still high value. In that case, in my example, the mass of VOCs leaving would be 1 pound. This is double the mass leaving when the destruction efficiency is 99.5%. So, a drop in the destruction efficiency from 99.5% to 99% results in a doubling of the emissions. Should the destruction efficiency drop to 98%, the outlet mass would increase to 2 pounds, or 4 times that when the efficiency was 99.5%. This is why it is critical that this important parameter, which so dramatically affects the estimated VOC emissions, be accurately measured and supported. In the present case, recall that Cameron's estimated VOC increase in M4 is 37.25 tons per year, and thus only slightly under the 40 tons per year threshold for triggering PSD. A large portion of this emissions increase is from the flare. It would take a very small decrease in the assumed VOC destruction efficiency to put the estimated increase over the PSD significance emission rate.

4. Misuse of AP-42 to Estimate PTE

In this section I discuss the inappropriateness of using AP-42 factors blindly, as has been done repeatedly, per the examples I showed earlier, to estimate the PTE emissions from various sources at Cameron for many pollutants including many highly hazardous and toxic compounds.

First, AP-42 emission factors are inappropriate for developing PTE estimates, since PTE, by design, is supposed to represent the "potential" or high-end emission estimate value while AP-42 emission factors represent "average" and not maximum emission rates. AP-42 makes this very clear:

> "In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i. e., a population average)."[10] (emphasis added)
>
> "Emission factor ratings in AP-42 (discussed below) provide indications of the robustness, or appropriateness, of emission factors for estimating average emissions for a source activity."[11] (emphasis added)

Thus, in each instance that the calculations in the September 2020 application and subsequent addenda rely on AP-42 emission factors, they are simply wrong and the resultant PTE emissions (all other criticisms aside) are underestimates. This has material consequences given how close the certain emissions are, for example NOx, in terms of their modeled impacts vis-à-vis the SIL.

Second, neither the September 2020 application nor the addenda nor the DEQ evaluations accompanying the proposed permit modifications and renewals mention or discuss the reliability (i.e., accuracy) of each of the many AP-42 emission factors used by Cameron. Not all emission factors in AP-42 are reliable and most are of very poor quality. AP-42 uses a rating system, quoted below, to provide the user with a sense of how accurate a particular emission factor is:

> "Each AP-42 emission factor is given a rating from A through E, with A being the best. A factor's rating is a general indication of the reliability, or robustness, of that factor. This rating is assigned based on the estimated reliability of the tests used to develop the factor and on both the amount and the representative characteristics of those data. In general, factors based on many observations, or on more widely accepted test procedures, are assigned higher rankings. Conversely, a factor based on a single observation of questionable quality, or one extrapolated from another factor for a similar process, would probably be rated much lower....
>
> The AP-42 emission factor rating is an overall assessment of how good a factor is, based on both the quality of the test(s) or information that is the source of the factor and on how well the factor represents the emission source. Higher ratings are for factors based on many unbiased observations, or on widely accepted test procedures. For example, ten or more source tests on different randomly selected plants would likely be assigned an "A" rating if all tests are conducted using a single valid reference measurement method. Likewise, a single observation based on questionable methods of testing would be assigned an "E", and a factor extrapolated from higher-rated factors for similar processes would be assigned a "D" or an "E".

AP-42 emission factor quality ratings are assigned as follows:

---

[10] AP-42 Introduction, p. 1. Available at https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors

[11] *Ibid.*, p. 2.

A — Excellent. Factor is developed from A- and B-rated source test data taken from many randomly chosen facilities in the industry population. The source category population is sufficiently specific to minimize variability.

B — Above average. Factor is developed from A- or B-rated test data from a "reasonable number" of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with an A rating, the source category population is sufficiently specific to minimize variability.

C — Average. Factor is developed from A-, B-, and/or C-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with the A rating, the source category population is sufficiently specific to minimize variability.

D — Below average. Factor is developed from A-, B- and/or C-rated test data from a small number of facilities, and there may be reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source population.

E — Poor. Factor is developed from C- and D-rated test data, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population."[12]

Note, in particular, the very poor reliabilities of "D" and "E" rated factors.

As another example, consider the use of AP-42, Chapter 1.4 [for Natural Gas combustion], Tables 1.4-1, 1.4-2, and 1.4-3, as well as metal HAP emission factors in Table 1.4-4 using in this instance, since there have been used in the calculations by Cameron. For ease of reference, I show below AP-42 Tables 1.4-1, 1.4-2, 1.4-3, and 1.4-4, without supporting footnotes.[13]

[12] *Ibid.*, pp. 8-10.

[13] The complete AP-42 Section is available at https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf

Table 1.4-1. EMISSION FACTORS FOR NITROGEN OXIDES (NO_x) AND CARBON MONOXIDE (CO) FROM NATURAL GAS COMBUSTION[a]

Combustor Type (MMBtu/hr Heat Input) [SCC]	NO_x[b]		CO	
	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
Large Wall-Fired Boilers (>100) [1-01-006-01, 1-02-006-01, 1-03-006-01]				
Uncontrolled (Pre-NSPS)[c]	280	A	84	B
Uncontrolled (Post-NSPS)[c]	190	A	84	B
Controlled - Low NO_x burners	140	A	84	B
Controlled - Flue gas recirculation	100	D	84	B
Small Boilers (<100) [1-01-006-02, 1-02-006-02, 1-03-006-02, 1-03-006-03]				
Uncontrolled	100	B	84	B
Controlled - Low NO_x burners	50	D	84	B
Controlled - Low NO_x burners/Flue gas recirculation	32	C	84	B
Tangential-Fired Boilers (All Sizes) [1-01-006-04]				
Uncontrolled	170	A	24	C
Controlled - Flue gas recirculation	76	D	98	D
Residential Furnaces (<0.3) [No SCC]				
Uncontrolled	94	B	40	B

TABLE 1.4-2. EMISSION FACTORS FOR CRITERIA POLLUTANTS AND GREENHOUSE GASES FROM NATURAL GAS COMBUSTION[a]

Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
CO_2[b]	120,000	A
Lead	0.0005	D
N_2O (Uncontrolled)	2.2	E
N_2O (Controlled-low-NO_x burner)	0.64	E
PM (Total)[c]	7.6	D
PM (Condensable)[c]	5.7	D
PM (Filterable)[c]	1.9	B
SO_2[d]	0.6	A
TOC	11	B
Methane	2.3	B
VOC	5.5	C

TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION[a]

CAS No.	Pollutant	Emission Factor (lb/10^6 scf)	Emission Factor Rating
91-57-6	2-Methylnaphthalene[b,c]	2.4E-05	D
56-49-5	3-Methylcholanthrene[b,c]	<1.8E-06	E
	7,12-Dimethylbenz(a)anthracene[b,c]	<1.6E-05	E
83-32-9	Acenaphthene[b,c]	<1.8E-06	E
203-96-8	Acenaphthylene[b,c]	<1.8E-06	E
120-12-7	Anthracene[b,c]	<2.4E-06	E
56-55-3	Benz(a)anthracene[b,c]	<1.8E-06	E
71-43-2	Benzene[b]	2.1E-03	B
50-32-8	Benzo(a)pyrene[b,c]	<1.2E-06	E
205-99-2	Benzo(b)fluoranthene[b,c]	<1.8E-06	E
191-24-2	Benzo(g,h,i)perylene[b,c]	<1.2E-06	E
207-08-9	Benzo(k)fluoranthene[b,c]	<1.8E-06	E
106-97-8	Butane	2.1E+00	E
218-01-9	Chrysene[b,c]	<1.8E-06	E
53-70-3	Dibenzo(a,h)anthracene[b,c]	<1.2E-06	E
25321-22-6	Dichlorobenzene[b]	1.2E-03	E
74-84-0	Ethane	3.1E+00	E
206-44-0	Fluoranthene[b,c]	3.0E-06	E
86-73-7	Fluorene[b,c]	2.8E-06	E
50-00-0	Formaldehyde[b]	7.5E-02	B
110-54-3	Hexane[b]	1.8E+00	E
193-39-5	Indeno(1,2,3-cd)pyrene[b,c]	<1.8E-06	E
91-20-3	Naphthalene[b]	6.1E-04	E
109-66-0	Pentane	2.6E+00	E
85-01-8	Phenanathrene[b,c]	1.7E-05	D
74-98-6	Propane	1.6E+00	E

TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION (Continued)

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
129-00-0	Pyrene[b, c]	5.0E-06	E
108-88-3	Toluene[b]	3.4E-03	C

TABLE 1.4-4. EMISSION FACTORS FOR METALS FROM NATURAL GAS COMBUSTION[a]

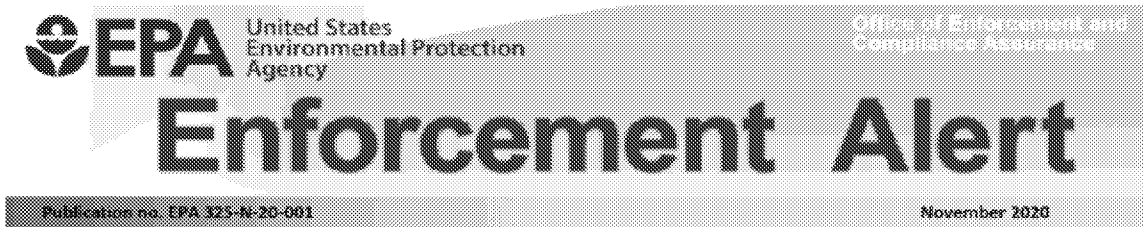
CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
7440-38-2	Arsenic[b]	2.0E-04	E
7440-39-3	Barium	4.4E-03	D
7440-41-7	Beryllium[b]	<1.2E-05	E
7440-43-9	Cadmium[b]	1.1E-03	D
7440-47-3	Chromium[b]	1.4E-03	D
7440-48-4	Cobalt[b]	8.4E-05	D
7440-50-8	Copper	8.5E-04	C
7439-96-5	Manganese[b]	3.8E-04	D
7439-97-6	Mercury[b]	2.6E-04	D
7439-98-7	Molybdenum	1.1E-03	D
7440-02-0	Nickel[b]	2.1E-03	C
7782-49-2	Selenium[b]	<2.4E-05	E
7440-62-2	Vanadium	2.3E-03	D
7440-66-6	Zinc	2.9E-02	E

It is clear from a review of the emission factor ratings provided in these tables above that many of them are generally rated at C, D, or E – i.e., indicating little to no accuracy. Yet, without commentary, the application and addenda and DEQ have used or accepted these poorly-rated emission factors as the basis for estimating the PTE emissions from numerous sources at Cameron.

Third, EPA has recently confirmed and specifically cautioned against the misuse of AP-42 for permitting precisely for the reasons stated above in an enforcement alert[14] issued in November

[14] https://www.epa.gov/compliance/epa-reminder-about-inappropriate-use-ap-42-emission-factors

2020, i.e., while Cameron was submitting its addenda and while DEQ was conducting its permit review. I provide a couple of excerpts below, with text highlighted by me.



EPA United States Environmental Protection Agency

Office of Enforcement and Compliance Assurance

Enforcement Alert

Publication no. EPA 325-N-20-001 November 2020

EPA Reminder About Inappropriate Use of AP-42 Emission Factors

Purpose

This purpose of this Enforcement Alert is to remind permitting agencies, consultants, and regulated entities that improperly using AP-42 emission factors can be costly to their businesses, inefficient, and in some circumstances, can subject regulated entities to enforcement and penalties. The Environmental Protection Agency (EPA) is concerned that some permitting agencies, consultants, and regulated entities may incorrectly be using AP-42 emission factors in place of more representative source-specific emission values for Clean Air Act permitting and compliance demonstration purposes.

Consequences of Using AP-42 Factors

Permitting agencies, consultants, and regulated entities should be aware that even emission factors with more highly rated AP-42 grades of "A" or "B" are only based on averages of data from multiple, albeit similar, sources (*See* the Attachment for an overview of the history of AP-42 emission factors and the AP-42 emission factor rating system). Accordingly, these factors are not likely to be accurate predictors of emissions from any one specific source, except in very limited scenarios. While emission factors are helpful in making emission estimates for area-wide inventories for specific source types, AP-42 provides the following warning:

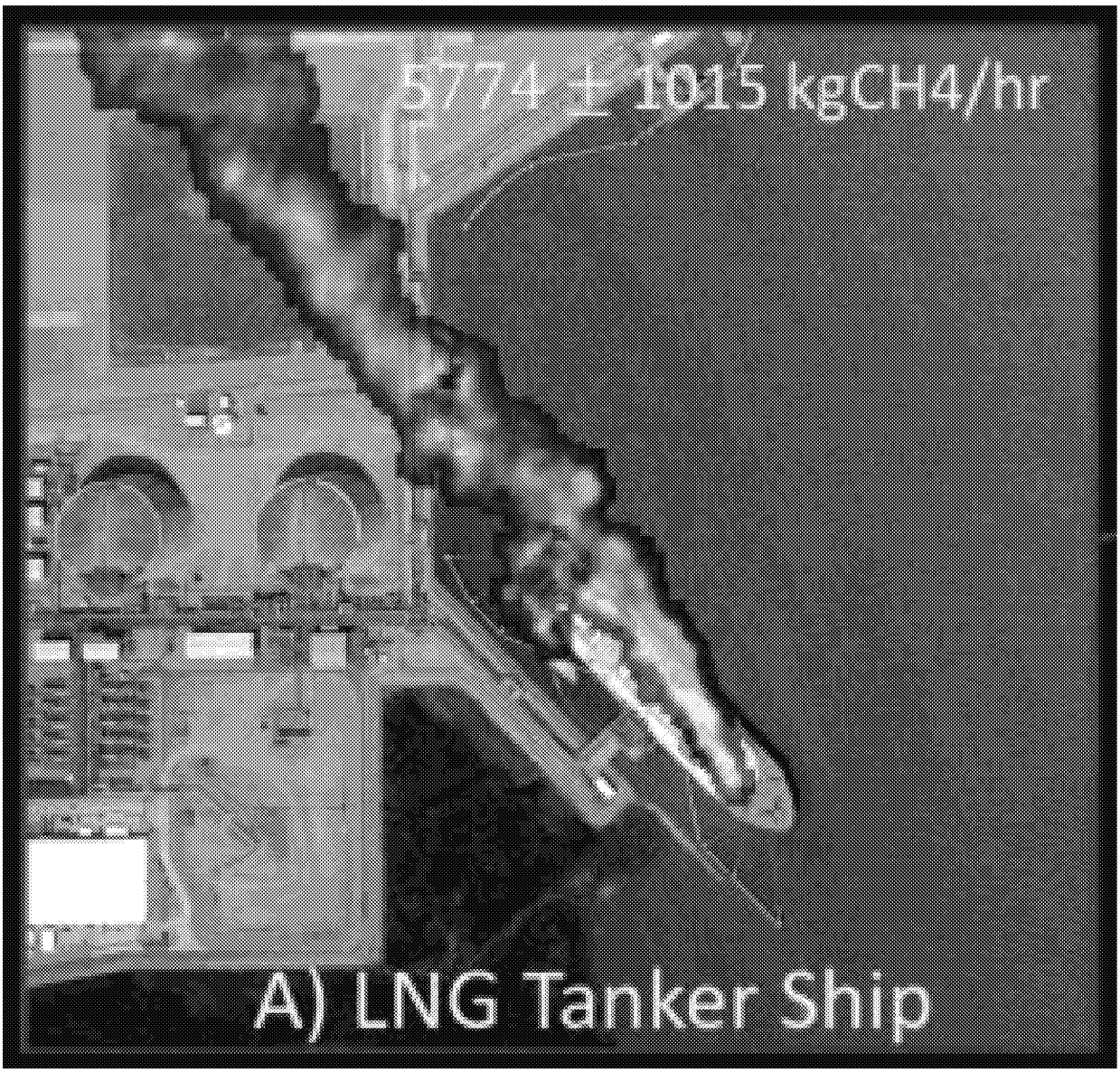
> "Use of these factors as source-specific permit limits and/or as emission regulation compliance determinations is not recommended by EPA. Because emission factors essentially represent an average of a range of emission rates, approximately half of the subject sources will have emission rates greater than the emission factor and the other half will have emission rates less than the factor. As such, a permit limit using an AP-42 emission factor would result in half of the sources being in noncompliance."

considered. **Remember, AP-42 emission factors should only be used as a last resort. Even then the facility assumes all risk associated with their use!**

Thus, based on all of the above, the PTE for most of the pollutants from most of the emissions sources at Cameron are either unsupported or underestimated.

As an example of how large emissions from the facility can be, the below image was provided to me following a recent flight over Cameron by Carbon Tracker, with an estimate emissions rate for methane, a potent greenhouse gas, along with the estimate of the measurement error also provided by Carbon Tracker.

The source of the methane appears to be from a ship located at a berth at Cameron. It is unclear as to which specific source or sources/activities is causing such emissions, supposedly from a vessel that should not be releasing methane, which is a saleable product from the facility.



H. Inadequate Monitoring Provisions and the Need for Additional Monitoring

Finally, in this section, I note that the entire permit contains only a few permit conditions relating to any monitoring or stack testing. Any reasonable permit, in my opinion, needs to contain far more testing and verification conditions, including the use of CEMS where appropriate.

(i) For example, NOx and CO CEMS, at, a minimum, should be required for the turbines. This is standard for BACT/LAER, as confirmed in one of the excerpts I have shown from the RBLC.

(ii) annual stack testing should be required for all pollutants (including TAPs) from all stack sources, including the turbines, the ground flare, and all combustion equipment;

(iii) the permit does not require any testing for condensable PM since the test method provided in the permit is Method 5, which only reports filterable PM. This is inappropriate. Both condensable and filterable PM should be measured.

(iv) the permit should contain conditions verifying the 99.5% destruction efficiency for VOCs in every instance that it is used – i.e., by concurrent inlet and outlet testing for each and all VOCs.

Attachment A

RANAJIT (RON) SAHU, Ph.D, QEP, CEM (Nevada)

CONSULTANT, ENVIRONMENTAL AND ENERGY ISSUES

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EXPERIENCE SUMMARY

Dr. Sahu has over thirty one years of experience in the fields of environmental, mechanical, and chemical engineering including: program and project management services; design and specification of pollution control equipment for a wide range of emissions sources including stationary and mobile sources; soils and groundwater remediation including landfills as remedy; combustion engineering evaluations; energy studies; multimedia environmental regulatory compliance (involving statutes and regulations such as the Federal CAA and its Amendments, Clean Water Act, TSCA, RCRA, CERCLA, SARA, OSHA, NEPA as well as various related state statutes); transportation air quality impact analysis; multimedia compliance audits; multimedia permitting (including air quality NSR/PSD permitting, Title V permitting, NPDES permitting for industrial and storm water discharges, RCRA permitting, etc.), multimedia/multi-pathway human health risk assessments for toxics; air dispersion modeling; and regulatory strategy development and support including negotiation of consent agreements and orders.

He has over twenty eight years of project management experience and has successfully managed and executed numerous projects in this time period. This includes basic and applied research projects, design projects, regulatory compliance projects, permitting projects, energy studies, risk assessment projects, and projects involving the communication of environmental data and information to the public.

He has provided consulting services to numerous private sector, public sector and public interest group clients. His major clients over the past twenty six years include various trade associations as well as individual companies such as steel mills, petroleum refineries, chemical plants, cement manufacturers, aerospace companies, power generation facilities, lawn and garden equipment manufacturers, spa manufacturers, chemical distribution facilities, land development companies, and various entities in the public sector including EPA, the US Dept. of Justice, several states (including Oregon, New Mexico, Pennsylvania, and others), various agencies such as the California DTSC, and various municipalities. Dr. Sahu has performed projects in all 50 states, numerous local jurisdictions and internationally.

In addition to consulting, for approximately twenty years, Dr. Sahu taught numerous courses in several Southern California universities including UCLA (air pollution), UC Riverside (air pollution, process hazard analysis), and Loyola Marymount University (air pollution, risk assessment, hazardous waste management). He also taught at Caltech, his alma mater (various engineering courses), at the University of Southern California (air pollution controls) and at California State University, Fullerton (transportation and air quality).

Dr. Sahu has and continues to provide expert witness services in a number of environmental areas discussed above in both state and Federal courts as well as before administrative bodies (please see Annex A).

EXPERIENCE RECORD

2000-present **Independent Consultant.** Providing a variety of private sector (industrial companies, land development companies, law firms, etc.), public sector (such as the US Department of Justice), and public interest group clients with project management, environmental consulting, project management, as well as regulatory and engineering support consulting services.

1995-2000 Parsons ES, **Associate, Senior Project Manager and Department Manager for** Air Quality/Geosciences/Hazardous Waste Groups, Pasadena. Responsible for the management of a group of approximately 24 air quality and environmental professionals, 15 geoscience, and 10

hazardous waste professionals providing full-service consulting, project management, regulatory compliance and A/E design assistance in all areas.

Parsons ES, **Manager for Air Source Testing Services**. Responsible for the management of 8 individuals in the area of air source testing and air regulatory permitting projects located in Bakersfield, California.

1992-1995 Engineering-Science, Inc. **Principal Engineer and Senior Project Manager** in the air quality department. Responsibilities included multimedia regulatory compliance and permitting (including hazardous and nuclear materials), air pollution engineering (emissions from stationary and mobile sources, control of criteria and air toxics, dispersion modeling, risk assessment, visibility analysis, odor analysis), supervisory functions and project management.

1990-1992 Engineering-Science, Inc. **Principal Engineer and Project Manager** in the air quality department. Responsibilities included permitting, tracking regulatory issues, technical analysis, and supervisory functions on numerous air, water, and hazardous waste projects. Responsibilities also include client and agency interfacing, project cost and schedule control, and reporting to internal and external upper management regarding project status.

1989-1990 Kinetics Technology International, Corp. **Development Engineer.** Involved in thermal engineering R&D and project work related to low-NOx ceramic radiant burners, fired heater NOx reduction, SCR design, and fired heater retrofitting.

1988-1989 Heat Transfer Research, Inc. **Research Engineer**. Involved in the design of fired heaters, heat exchangers, air coolers, and other non-fired equipment. Also did research in the area of heat exchanger tube vibrations.

EDUCATION

1984-1988 Ph.D., Mechanical Engineering, California Institute of Technology (Caltech), Pasadena, CA.

1984 M. S., Mechanical Engineering, California Institute of Technology (Caltech), Pasadena, CA.

1978-1983 B. Tech (Honors), Mechanical Engineering, Indian Institute of Technology (IIT) Kharagpur, India

TEACHING EXPERIENCE

Caltech

"Thermodynamics," Teaching Assistant, California Institute of Technology, 1983, 1987.

"Air Pollution Control," Teaching Assistant, California Institute of Technology, 1985.

"Caltech Secondary and High School Saturday Program," - taught various mathematics (algebra through calculus) and science (physics and chemistry) courses to high school students, 1983-1989.

"Heat Transfer," - taught this course in the Fall and Winter terms of 1994-1995 in the Division of Engineering and Applied Science.

"Thermodynamics and Heat Transfer," Fall and Winter Terms of 1996-1997.

U.C. Riverside, Extension

"Toxic and Hazardous Air Contaminants," University of California Extension Program, Riverside, California. Various years since 1992.

"Prevention and Management of Accidental Air Emissions," University of California Extension Program, Riverside, California. Various years since 1992.

"Air Pollution Control Systems and Strategies," University of California Extension Program, Riverside, California, Summer 1992-93, Summer 1993-1994.

"Air Pollution Calculations," University of California Extension Program, Riverside, California, Fall 1993-94, Winter 1993-94, Fall 1994-95.

"Process Safety Management," University of California Extension Program, Riverside, California. Various years since 1992-2010.

"Process Safety Management," University of California Extension Program, Riverside, California, at SCAQMD, Spring 1993-94.

"Advanced Hazard Analysis - A Special Course for LEPCs," University of California Extension Program, Riverside, California, taught at San Diego, California, Spring 1993-1994.

"Advanced Hazardous Waste Management" University of California Extension Program, Riverside, California. 2005.

Loyola Marymount University

"Fundamentals of Air Pollution - Regulations, Controls and Engineering," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1993.

"Air Pollution Control," Loyola Marymount University, Dept. of Civil Engineering, Fall 1994.

"Environmental Risk Assessment," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1998.

"Hazardous Waste Remediation" Loyola Marymount University, Dept. of Civil Engineering. Various years since 2006.

University of Southern California

"Air Pollution Controls," University of Southern California, Dept. of Civil Engineering, Fall 1993, Fall 1994.

"Air Pollution Fundamentals," University of Southern California, Dept. of Civil Engineering, Winter 1994.

University of California, Los Angeles

"Air Pollution Fundamentals," University of California, Los Angeles, Dept. of Civil and Environmental Engineering, Spring 1994, Spring 1999, Spring 2000, Spring 2003, Spring 2006, Spring 2007, Spring 2008, Spring 2009.

International Programs

"Environmental Planning and Management," 5 week program for visiting Chinese delegation, 1994.

"Environmental Planning and Management," 1 day program for visiting Russian delegation, 1995.

"Air Pollution Planning and Management," IEP, UCR, Spring 1996.

"Environmental Issues and Air Pollution," IEP, UCR, October 1996.

PROFESSIONAL AFFILIATIONS AND HONORS

President of India Gold Medal, IIT Kharagpur, India, 1983.

Member of the Alternatives Assessment Committee of the Grand Canyon Visibility Transport Commission, established by the Clean Air Act Amendments of 1990, 1992.

American Society of Mechanical Engineers: Los Angeles Section Executive Committee, Heat Transfer Division, and Fuels and Combustion Technology Division, 1987-mid-1990s.

Air and Waste Management Association, West Coast Section, 1989-mid-2000s.

PROFESSIONAL CERTIFICATIONS

EIT, California (#XE088305), 1993.

REA I, California (#07438), 2000.

Certified Permitting Professional, South Coast AQMD (#C8320), since 1993.

QEP, Institute of Professional Environmental Practice, since 2000.

CEM, State of Nevada (#EM-1699). Expiration 10/07/2021.

PUBLICATIONS (PARTIAL LIST)

"Physical Properties and Oxidation Rates of Chars from Bituminous Coals," with Y.A. Levendis, R.C. Flagan and G.R. Gavalas, *Fuel*, **67**, 275-283 (1988).

"Char Combustion: Measurement and Analysis of Particle Temperature Histories," with R.C. Flagan, G.R. Gavalas and P.S. Northrop, *Comb. Sci. Tech.* **60**, 215-230 (1988).

"On the Combustion of Bituminous Coal Chars," PhD Thesis, California Institute of Technology (1988).

"Optical Pyrometry: A Powerful Tool for Coal Combustion Diagnostics," *J. Coal Quality*, **8**, 17-22 (1989).

"Post-Ignition Transients in the Combustion of Single Char Particles," with Y.A. Levendis, R.C. Flagan and G.R. Gavalas, *Fuel*, **68**, 849-855 (1989).

"A Model for Single Particle Combustion of Bituminous Coal Char." Proc. ASME National Heat Transfer Conference, Philadelphia, **HTD-Vol. 106**, 505-513 (1989).

"Discrete Simulation of Cenospheric Coal-Char Combustion," with R.C. Flagan and G.R. Gavalas, *Combust. Flame*, **77**, 337-346 (1989).

"Particle Measurements in Coal Combustion," with R.C. Flagan, in "**Combustion Measurements**" (ed. N. Chigier), Hemisphere Publishing Corp. (1991).

"Cross Linking in Pore Structures and Its Effect on Reactivity," with G.R. Gavalas in preparation.

"Natural Frequencies and Mode Shapes of Straight Tubes," Proprietary Report for Heat Transfer Research Institute, Alhambra, CA (1990).

"Optimal Tube Layouts for Kamui SL-Series Exchangers," with K. Ishihara, Proprietary Report for Kamui Company Limited, Tokyo, Japan (1990).

"HTRI Process Heater Conceptual Design," Proprietary Report for Heat Transfer Research Institute, Alhambra, CA (1990).

"Asymptotic Theory of Transonic Wind Tunnel Wall Interference," with N.D. Malmuth and others, Arnold Engineering Development Center, Air Force Systems Command, USAF (1990).

"Gas Radiation in a Fired Heater Convection Section," Proprietary Report for Heat Transfer Research Institute, College Station, TX (1990).

"Heat Transfer and Pressure Drop in NTIW Heat Exchangers," Proprietary Report for Heat Transfer Research Institute, College Station, TX (1991).

"NOx Control and Thermal Design," Thermal Engineering Tech Briefs, (1994).

"From Purchase of Landmark Environmental Insurance to Remediation: Case Study in Henderson, Nevada," with Robin E. Bain and Jill Quillin, presented at the AQMA Annual Meeting, Florida, 2001.

"The Jones Act Contribution to Global Warming, Acid Rain and Toxic Air Contaminants," with Charles W. Botsford, presented at the AQMA Annual Meeting, Florida, 2001.

PRESENTATIONS (PARTIAL LIST)

"Pore Structure and Combustion Kinetics - Interpretation of Single Particle Temperature-Time Histories," with P.S. Northrop, R.C. Flagan and G.R. Gavalas, presented at the AIChE Annual Meeting, New York (1987).

"Measurement of Temperature-Time Histories of Burning Single Coal Char Particles," with R.C. Flagan, presented at the American Flame Research Committee Fall International Symposium, Pittsburgh, (1988).

"Physical Characterization of a Cenospheric Coal Char Burned at High Temperatures," with R.C. Flagan and G.R. Gavalas, presented at the Fall Meeting of the Western States Section of the Combustion Institute, Laguna Beach, California (1988).

"Control of Nitrogen Oxide Emissions in Gas Fired Heaters - The Retrofit Experience," with G. P. Croce and R. Patel, presented at the International Conference on Environmental Control of Combustion Processes (Jointly sponsored by the American Flame Research Committee and the Japan Flame Research Committee), Honolulu, Hawaii (1991).

"Air Toxics - Past, Present and the Future," presented at the Joint AIChE/AAEE Breakfast Meeting at the AIChE 1991 Annual Meeting, Los Angeles, California, November 17-22 (1991).

"Air Toxics Emissions and Risk Impacts from Automobiles Using Reformulated Gasolines," presented at the Third Annual Current Issues in Air Toxics Conference, Sacramento, California, November 9-10 (1992).

"Air Toxics from Mobile Sources," presented at the Environmental Health Sciences (ESE) Seminar Series, UCLA, Los Angeles, California, November 12, (1992).

"Kilns, Ovens, and Dryers - Present and Future," presented at the Gas Company Air Quality Permit Assistance Seminar, Industry Hills Sheraton, California, November 20, (1992).

"The Design and Implementation of Vehicle Scrapping Programs," presented at the 86th Annual Meeting of the Air and Waste Management Association, Denver, Colorado, June 12, 1993.

"Air Quality Planning and Control in Beijing, China," presented at the 87th Annual Meeting of the Air and Waste Management Association, Cincinnati, Ohio, June 19-24, 1994.

Annex A

Expert Litigation Support

A. Occasions where Dr. Sahu has provided Written or Oral testimony before Congress:

1. In July 2012, provided expert written and oral testimony to the House Subcommittee on Energy and the Environment, Committee on Science, Space, and Technology at a Hearing entitled "Hitting the Ethanol Blend Wall – Examining the Science on E15."

B. Matters for which Dr. Sahu has provided affidavits and expert reports include:

2. Affidavit for Rocky Mountain Steel Mills, Inc. located in Pueblo Colorado – dealing with the technical uncertainties associated with night-time opacity measurements in general and at this steel mini-mill.

3. Expert reports and depositions (2/28/2002 and 3/1/2002; 12/2/2003 and 12/3/2003; 5/24/2004) on behalf of the United States in connection with the Ohio Edison NSR Cases. *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (Southern District of Ohio).

4. Expert reports and depositions (5/23/2002 and 5/24/2002) on behalf of the United States in connection with the Illinois Power NSR Case. *United States v. Illinois Power Co., et al.*, 99-833-MJR (Southern District of Illinois).

5. Expert reports and depositions (11/25/2002 and 11/26/2002) on behalf of the United States in connection with the Duke Power NSR Case. *United States, et al. v. Duke Energy Corp.*, 1:00-CV-1262 (Middle District of North Carolina).

6. Expert reports and depositions (10/6/2004 and 10/7/2004; 7/10/2006) on behalf of the United States in connection with the American Electric Power NSR Cases. *United States, et al. v. American Electric Power Service Corp., et al.*, C2-99-1182, C2-99-1250 (Southern District of Ohio).

7. Affidavit (March 2005) on behalf of the Minnesota Center for Environmental Advocacy and others in the matter of the Application of Heron Lake BioEnergy LLC to construct and operate an ethanol production facility – submitted to the Minnesota Pollution Control Agency.

8. Expert Report and Deposition (10/31/2005 and 11/1/2005) on behalf of the United States in connection with the East Kentucky Power Cooperative NSR Case. *United States v. East Kentucky Power Cooperative, Inc.*, 5:04-cv-00034-KSF (Eastern District of Kentucky).

9. Affidavits and deposition on behalf of Basic Management Inc. (BMI) Companies in connection with the BMI vs. USA remediation cost recovery Case.

10. Expert Report on behalf of Penn Future and others in the Cambria Coke plant permit challenge in Pennsylvania.

11. Expert Report on behalf of the Appalachian Center for the Economy and the Environment and others in the Western Greenbrier permit challenge in West Virginia.

12. Expert Report, deposition (via telephone on January 26, 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) in the Thompson River Cogeneration LLC Permit No. 3175-04 challenge.

13. Expert Report and deposition (2/2/07) on behalf of the Texas Clean Air Cities Coalition at the Texas State Office of Administrative Hearings (SOAH) in the matter of the permit challenges to TXU Project Apollo's eight new proposed PRB-fired PC boilers located at seven TX sites.

14. Expert Testimony (July 2007) on behalf of the Izaak Walton League of America and others in connection with the acquisition of power by Xcel Energy from the proposed Gascoyne Power Plant – at the State of

Minnesota, Office of Administrative Hearings for the Minnesota PUC (MPUC No. E002/CN-06-1518; OAH No. 12-2500-17857-2).

15. Affidavit (July 2007) Comments on the Big Cajun I Draft Permit on behalf of the Sierra Club – submitted to the Louisiana DEQ.

16. Expert Report and Deposition (12/13/2007) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case. *Plaintiffs v. Allegheny Energy Inc., et al.,* 2:05cv0885 (Western District of Pennsylvania).

17. Expert Reports and Pre-filed Testimony before the Utah Air Quality Board on behalf of Sierra Club in the Sevier Power Plant permit challenge.

18. Expert Report and Deposition (October 2007) on behalf of MTD Products Inc., in connection with *General Power Products, LLC v MTD Products Inc.*, 1:06 CVA 0143 (Southern District of Ohio, Western Division) .

19. Expert Report and Deposition (June 2008) on behalf of Sierra Club and others in the matter of permit challenges (Title V: 28.0801-29 and PSD: 28.0803-PSD) for the Big Stone II unit, proposed to be located near Milbank, South Dakota.

20. Expert Reports, Affidavit, and Deposition (August 15, 2008) on behalf of Earthjustice in the matter of air permit challenge (CT-4631) for the Basin Electric Dry Fork station, under construction near Gillette, Wyoming before the Environmental Quality Council of the State of Wyoming.

21. Affidavits (May 2010/June 2010 in the Office of Administrative Hearings))/Declaration and Expert Report (November 2009 in the Office of Administrative Hearings) on behalf of NRDC and the Southern Environmental Law Center in the matter of the air permit challenge for Duke Cliffside Unit 6. Office of Administrative Hearing Matters 08 EHR 0771, 0835 and 0836 and 09 HER 3102, 3174, and 3176 (consolidated).

22. Declaration (August 2008), Expert Report (January 2009), and Declaration (May 2009) on behalf of Southern Alliance for Clean Energy in the matter of the air permit challenge for Duke Cliffside Unit 6. *Southern Alliance for Clean Energy et al., v. Duke Energy Carolinas, LLC*, Case No. 1:08-cv-00318-LHT-DLH (Western District of North Carolina, Asheville Division).

23. Declaration (August 2008) on behalf of the Sierra Club in the matter of Dominion Wise County plant MACT.us

24. Expert Report (June 2008) on behalf of Sierra Club for the Green Energy Resource Recovery Project, MACT Analysis.

25. Expert Report (February 2009) on behalf of Sierra Club and the Environmental Integrity Project in the matter of the air permit challenge for NRG Limestone's proposed Unit 3 in Texas.

26. Expert Report (June 2009) on behalf of MTD Products, Inc., in the matter of *Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al.*

27. Expert Report (August 2009) on behalf of Sierra Club and the Southern Environmental Law Center in the matter of the air permit challenge for Santee Cooper's proposed Pee Dee plant in South Carolina).

28. Statements (May 2008 and September 2009) on behalf of the Minnesota Center for Environmental Advocacy to the Minnesota Pollution Control Agency in the matter of the Minnesota Haze State Implementation Plans.

29. Expert Report (August 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

30. Expert Report and Rebuttal Report (September 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.

31. Expert Report (December 2009) and Rebuttal reports (May 2010 and June 2010) on behalf of the United States in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).

32. Pre-filed Testimony (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

33. Pre-filed Testimony (July 2010) and Written Rebuttal Testimony (August 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions,* No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.

34. Expert Report (August 2010) and Rebuttal Expert Report (October 2010) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Liability Phase.

35. Declaration (August 2010), Reply Declaration (November 2010), Expert Report (April 2011), Supplemental and Rebuttal Expert Report (July 2011) on behalf of the United States in the matter of DTE Energy Company and Detroit Edison Company (Monroe Unit 2). *United States of America v. DTE Energy Company and Detroit Edison Company*, Civil Action No. 2:10-cv-13101-BAF-RSW (Eastern District of Michigan).

36. Expert Report and Deposition (August 2010) as well as Affidavit (September 2010) on behalf of Kentucky Waterways Alliance, Sierra Club, and Valley Watch in the matter of challenges to the NPDES permit issued for the Trimble County power plant by the Kentucky Energy and Environment Cabinet to Louisville Gas and Electric, File No. DOW-41106-047.

37. Expert Report (August 2010), Rebuttal Expert Report (September 2010), Supplemental Expert Report (September 2011), and Declaration (November 2011) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (District of Colorado).

38. Written Direct Expert Testimony (August 2010) and Affidavit (February 2012) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).

39. Deposition (August 2010) on behalf of Environmental Defense, in the matter of the remanded permit challenge to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

40. Expert Report, Supplemental/Rebuttal Expert Report, and Declarations (October 2010, November 2010, September 2012) on behalf of New Mexico Environment Department (Plaintiff-Intervenor), Grand Canyon Trust and Sierra Club (Plaintiffs) in the matter of *Plaintiffs v. Public Service Company of New Mexico* (PNM), Civil No. 1:02-CV-0552 BB/ATC (ACE) (District of New Mexico).

41. Expert Report (October 2010) and Rebuttal Expert Report (November 2010) (BART Determinations for PSCo Hayden and CSU Martin Drake units) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.

42. Expert Report (November 2010) (BART Determinations for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.

43. Declaration (November 2010) on behalf of the Sierra Club in connection with the Martin Lake Station Units 1, 2, and 3. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Case No. 5:10-cv-00156-DF-CMC (Eastern District of Texas, Texarkana Division).

44. Pre-Filed Testimony (January 2011) and Declaration (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).

45. Declaration (February 2011) in the matter of the Draft Title V Permit for RRI Energy MidAtlantic Power Holdings LLC Shawville Generating Station (Pennsylvania), ID No. 17-00001 on behalf of the Sierra Club.

46. Expert Report (March 2011), Rebuttal Expert Report (June 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (District of Colorado).

47. Declaration (April 2011) and Expert Report (July 16, 2012) in the matter of the Lower Colorado River Authority (LCRA)'s Fayette (Sam Seymour) Power Plant on behalf of the Texas Campaign for the Environment. *Texas Campaign for the Environment v. Lower Colorado River Authority,* Civil Action No. 4:11-cv-00791 (Southern District of Texas, Houston Division).

48. Declaration (June 2011) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.

49. Expert Report (June 2011) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).

50. Declaration (August 2011) in the matter of the Sandy Creek Energy Associates L.P. Sandy Creek Power Plant on behalf of Sierra Club and Public Citizen. *Sierra Club, Inc. and Public Citizen, Inc. v. Sandy Creek Energy Associates, L.P.,* Civil Action No. A-08-CA-648-LY (Western District of Texas, Austin Division).

51. Expert Report (October 2011) on behalf of the Defendants in the matter of *John Quiles and Jeanette Quiles et al. v. Bradford-White Corporation, MTD Products, Inc., Kohler Co., et al.,* Case No. 3:10-cv-747 (TJM/DEP) (Northern District of New York).

52. Declaration (October 2011) on behalf of the Plaintiffs in the matter of *American Nurses Association et. al. (Plaintiffs), v. US EPA (Defendant)*, Case No. 1:08-cv-02198-RMC (US District Court for the District of Columbia).

53. Declaration (February 2012) and Second Declaration (February 2012) in the matter of *Washington Environmental Council and Sierra Club Washington State Chapter v. Washington State Department of Ecology and Western States Petroleum Association,* Case No. 11-417-MJP (Western District of Washington).

54. Expert Report (March 2012) and Supplemental Expert Report (November 2013) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.,* Civil Action No. 4:10-cv-4969 (Southern District of Texas, Houston Division).

55. Declaration (March 2012) in the matter of *Center for Biological Diversity, et al. v. United States Environmental Protection Agency,* Case No. 11-1101 (consolidated with 11-1285, 11-1328 and 11-1336) (US Court of Appeals for the District of Columbia Circuit).

56. Declaration (March 2012) in the matter of *Sierra Club v. The Kansas Department of Health and Environment*, Case No. 11-105,493-AS (Holcomb power plant) (Supreme Court of the State of Kansas).

57. Declaration (March 2012) in the matter of the Las Brisas Energy Center *Environmental Defense Fund et al., v. Texas Commission on Environmental Quality,* Cause No. D-1-GN-11-001364 (District Court of Travis County, Texas, 261st Judicial District).

58. Expert Report (April 2012), Supplemental and Rebuttal Expert Report (July 2012), and Supplemental Rebuttal Expert Report (August 2012) on behalf of the states of New Jersey and Connecticut in the matter of the Portland Power plant *State of New Jersey and State of Connecticut (Intervenor-Plaintiff) v. RRI Energy Mid-Atlantic Power Holdings et al.,* Civil Action No. 07-CV-5298 (JKG) (Eastern District of Pennsylvania).

59. Declaration (April 2012) in the matter of the EPA's EGU MATS Rule, on behalf of the Environmental Integrity Project.

60. Expert Report (August 2012) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Harm Phase.

61. Declaration (September 2012) in the Matter of the Application of *Energy Answers Incinerator, Inc.* for a Certificate of Public Convenience and Necessity to Construct a 120 MW Generating Facility in Baltimore City, Maryland, before the Public Service Commission of Maryland, Case No. 9199.

62. Expert Report (October 2012) on behalf of the Appellants (Robert Concilus and Leah Humes) in the matter of Robert Concilus and Leah Humes v. Commonwealth of Pennsylvania Department of Environmental Protection and Crawford Renewable Energy, before the Commonwealth of Pennsylvania Environmental Hearing Board, Docket No. 2011-167-R.

63. Expert Report (October 2012), Supplemental Expert Report (January 2013), and Affidavit (June 2013) in the matter of various Environmental Petitioners v. North Carolina DENR/DAQ and Carolinas Cement Company, before the Office of Administrative Hearings, State of North Carolina.

64. Pre-filed Testimony (October 2012) on behalf of No-Sag in the matter of the North Springfield Sustainable Energy Project before the State of Vermont, Public Service Board.

65. Pre-filed Testimony (November 2012) on behalf of Clean Wisconsin in the matter of Application of Wisconsin Public Service Corporation for Authority to Construct and Place in Operation a New Multi-Pollutant Control Technology System (ReACT) for Unit 3 of the Weston Generating Station, before the Public Service Commission of Wisconsin, Docket No. 6690-CE-197.

66. Expert Report (February 2013) on behalf of Petitioners in the matter of Credence Crematory, Cause No. 12-A-J-4538 before the Indiana Office of Environmental Adjudication.

67. Expert Report (April 2013), Rebuttal report (July 2013), and Declarations (October 2013, November 2013) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).

68. Declaration (April 2013) on behalf of Petitioners in the matter of *Sierra Club, et al., (Petitioners) v Environmental Protection Agency et al. (Resppondents),* Case No., 13-1112, (Court of Appeals, District of Columbia Circuit).

69. Expert Report (May 2013) and Rebuttal Expert Report (July 2013) on behalf of the Sierra Club in connection with the Luminant Martin Lake Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 5:10-cv-0156-MHS-CMC (Eastern District of Texas, Texarkana Division).

70. Declaration (August 2013) on behalf of A. J. Acosta Company, Inc., in the matter of *A. J. Acosta Company, Inc., v. County of San Bernardino*, Case No. CIVSS803651.

71. Comments (October 2013) on behalf of the Washington Environmental Council and the Sierra Club in the matter of the Washington State Oil Refinery RACT (for Greenhouse Gases), submitted to the Washington State Department of Ecology, the Northwest Clean Air Agency, and the Puget Sound Clean Air Agency.

72. Statement (November 2013) on behalf of various Environmental Organizations in the matter of the Boswell Energy Center (BEC) Unit 4 Environmental Retrofit Project, to the Minnesota Public Utilities Commission, Docket No. E-015/M-12-920.

73. Expert Report (December 2013) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).

74. Expert Testimony (December 2013) on behalf of the Sierra Club in the matter of Public Service Company of New Hampshire Merrimack Station Scrubber Project and Cost Recovery, Docket No. DE 11-250, to the State of New Hampshire Public Utilities Commission.

75. Expert Report (January 2014) on behalf of Baja, Inc., in *Baja, Inc., v. Automotive Testing and Development Services, Inc. et. al*, Civil Action No. 8:13-CV-02057-GRA (District of South Carolina, Anderson/Greenwood Division).

76. Declaration (March 2014) on behalf of the Center for International Environmental Law, Chesapeake Climate Action Network, Friends of the Earth, Pacific Environment, and the Sierra Club (Plaintiffs) in the matter of *Plaintiffs v. the Export-Import Bank (Ex-Im Bank) of the United States*, Civil Action No. 13-1820 RC (District Court for the District of Columbia).

77. Declaration (April 2014) on behalf of Respondent-Intervenors in the matter of *Mexichem Specialty Resins Inc., et al., (Petitioners) v Environmental Protection Agency et al.,* Case No., 12-1260 (and Consolidated Case Nos. 12-1263, 12-1265, 12-1266, and 12-1267), (Court of Appeals, District of Columbia Circuit).

78. Direct Prefiled Testimony (June 2014) on behalf of the Michigan Environmental Council and the Sierra Club in the matter of the Application of DTE Electric Company for Authority to Implement a Power Supply Cost Recovery (PSCR) Plan in its Rate Schedules for 2014 Metered Jurisdictional Sales of Electricity, Case No. U-17319 (Michigan Public Service Commission).

79. Expert Report (June 2014) on behalf of ECM Biofilms in the matter of the US Federal Trade Commission (FTC) v. ECM Biofilms (FTC Docket #9358).

80. Direct Prefiled Testimony (August 2014) on behalf of the Michigan Environmental Council and the Sierra Club in the matter of the Application of Consumers Energy Company for Authority to Implement a Power Supply Cost Recovery (PSCR) Plan in its Rate Schedules for 2014 Metered Jurisdictional Sales of Electricity, Case No. U-17317 (Michigan Public Service Commission).

81. Declaration (July 2014) on behalf of Public Health Intervenors in the matter of *EME Homer City Generation v. US EPA* (Case No. 11-1302 and consolidated cases) relating to the lifting of the stay entered by the Court on December 30, 2011 (US Court of Appeals for the District of Columbia).

82. Expert Report (September 2014), Rebuttal Expert Report (December 2014) and Supplemental Expert Report (March 2015) on behalf of Plaintiffs in the matter of *Sierra Club and Montana Environmental Information Center (Plaintiffs) v. PPL Montana LLC, Avista Corporation, Puget Sound Energy, Portland General Electric Company, Northwestern Corporation, and Pacificorp (Defendants)*, Civil Action No. CV 13-32-BLG-DLC-JCL (US District Court for the District of Montana, Billings Division).

83. Expert Report (November 2014) on behalf of Niagara County, the Town of Lewiston, and the Villages of Lewiston and Youngstown in the matter of CWM Chemical Services, LLC New York State Department of Environmental Conservation (NYSDEC) Permit Application Nos.: 9-2934-00022/00225, 9-2934-00022/00231, 9-2934-00022/00232, and 9-2934-00022/00249 (pending).

84. *Declaration (January 2015) relating to Startup/Shutdown in the MATS Rule (EPA Docket ID No. EPA-HQ-OAR-2009-0234) on behalf of the Environmental Integrity Project.*

85. Pre-filed Direct Testimony (March 2015), Supplemental Testimony (May 2015), and Surrebuttal Testimony (December 2015) on behalf of Friends of the Columbia Gorge in the matter of the Application for a Site Certificate for the Troutdale Energy Center before the Oregon Energy Facility Siting Council.

86. Brief of Amici Curiae Experts in Air Pollution Control and Air Quality Regulation in Support of the Respondents, On Writs of Certiorari to the US Court of Appeals for the District of Columbia, No. 14-46, 47, 48. *Michigan et. al., (Petitioners) v. EPA et. al., Utility Air Regulatory Group (Petitioners) v. EPA et. al., National Mining Association et. al., (Petitioner) v. EPA et. al.,* (Supreme Court of the United States).

87. Expert Report (March 2015) and Rebuttal Expert Report (January 2016) on behalf of Plaintiffs in the matter of *Conservation Law Foundation v. Broadrock Gas Services LLC, Rhode Island LFG GENCO LLC, and Rhode Island Resource Recovery Corporation (Defendants)*, Civil Action No. 1:13-cv-00777-M-PAS (US District Court for the District of Rhode Island).

88. Declaration (April 2015) relating to various Technical Corrections for the MATS Rule (EPA Docket ID No. EPA-HQ-OAR-2009-0234) on behalf of the Environmental Integrity Project.

89. Direct Prefiled Testimony (May 2015) on behalf of the Michigan Environmental Council, the Natural Resources Defense Council, and the Sierra Club in the matter of the Application of DTE Electric Company for Authority to Increase its Rates, Amend its Rate Schedules and Rules Governing the Distribution and Supply of Electric Energy and for Miscellaneous Accounting Authority, Case No. U-17767 (Michigan Public Service Commission).

90. Expert Report (July 2015) and Rebuttal Expert Report (July 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

91. Declaration (August 2015, Docket No. 1570376) in support of "Opposition of Respondent-Intervenors American Lung Association, et. al., to Tri-State Generation's Emergency Motion;" Declaration (September 2015, Docket No. 1574820) in support of "Joint Motion of the State, Local Government, and Public Health Respondent-Intervenors for Remand Without Vacatur;" Declaration (October 2015) in support of "Joint Motion of the State, Local Government, and Public Health Respondent-Intervenors to State and Certain Industry Petitioners' Motion to Govern, *White Stallion Energy Center, LLC v. US EPA*, Case No. 12-1100 (US Court of Appeals for the District of Columbia).

92. Declaration (September 2015) in support of the Draft Title V Permit for Dickerson Generating Station (Proposed Permit No 24-031-0019) on behalf of the Environmental Integrity Project.

93. Expert Report (Liability Phase) (December 2015) and Rebuttal Expert Report (February 2016) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., Environmental Law and Policy Center, and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).

94. Declaration (December 2015) in support of the Petition to Object to the Title V Permit for Morgantown Generating Station (Proposed Permit No 24-017-0014) on behalf of the Environmental Integrity Project.

95. Expert Report (November 2015) on behalf of Appellants in the matter of *Sierra Club, et al. v. Craig W. Butler, Director of Ohio Environmental Protection Agency et al.,* ERAC Case No. 14-256814.

96. Affidavit (January 2016) on behalf of Bridgewatch Detroit in the matter of *Bridgewatch Detroit v. Waterfront Petroleum Terminal Co., and Waterfront Terminal Holdings, LLC.*, in the Circuit Court for the County of Wayne, State of Michigan.

97. Expert Report (February 2016) and Rebuttal Expert Report (July 2016) on behalf of the challengers in the matter of the Delaware Riverkeeper Network, Clean Air Council, et. al., vs. Commonwealth of Pennsylvania Department of Environmental Protection and R. E. Gas Development LLC regarding the Geyer well site before the Pennsylvania Environmental Hearing Board.

98. Direct Testimony (May 2016) in the matter of Tesoro Savage LLC Vancouver Energy Distribution Terminal, Case No. 15-001 before the State of Washington Energy Facility Site Evaluation Council.

99. Declaration (June 2016) relating to deficiencies in air quality analysis for the proposed Millenium Bulk Terminal, Port of Longview, Washington.

100. Declaration (December 2016) relating to EPA's refusal to set limits on PM emissions from coal-fired power plants that reflect pollution reductions achievable with fabric filters on behalf of Environmental Integrity Project, Clean Air Council, Chesapeake Climate Action Network, Downwinders at Risk represented by Earthjustice in the matter of *ARIPPA v EPA, Case No. 15-1180.* (D.C. Circuit Court of Appeals).

101. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Huntley and Huntley Poseidon Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

102. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Backus Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

103. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Drakulic Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

104. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Deutsch Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

105. Affidavit (February 2017) pertaining to deficiencies water discharge compliance issues at the Wood River Refinery in the matter of *People of the State of Illinois (Plaintiff) v. Phillips 66 Company, ConocoPhillips Company, WRB Refining LP (Defendants)*, Case No. 16-CH-656, (Circuit Court for the Third Judicial Circuit, Madison County, Illinois).

106. Expert Report (March 2017) on behalf of the Plaintiff pertaining to non-degradation analysis for waste water discharges from a power plant in the matter of *Sierra Club (Plaintiff) v. Pennsylvania Department of Environmental Protection (PADEP) and Lackawanna Energy Center*, Docket No. 2016-047-L (consolidated), (Pennsylvania Environmental Hearing Board).

107. Expert Report (March 2017) on behalf of the Plaintiff pertaining to air emissions from the Heritage incinerator in East Liverpool, Ohio in the matter of *Save our County (Plaintiff) v. Heritage Thermal Services, Inc. (Defendant), Case No. 4:16-CV-1544-BYP*, (US District Court for the Northern District of Ohio, Eastern Division).

108. Rebuttal Expert Report (June 2017) on behalf of Plaintiffs in the matter of *Casey Voight and Julie Voight (Plaintiffs) v Coyote Creek Mining Company LLC (Defendant),* Civil Action No. 1:15-CV-00109 (US District Court for the District of North Dakota, Western Division).

109. Expert Affidavit (August 2017) and Penalty/Remedy Expert Affidavit (October 2017) on behalf of Plaintiff in the matter of *Wildearth Guardians (Plaintiff) v Colorado Springs Utility Board (Defendant,)* Civil Action No. 1:15-cv-00357-CMA-CBS (US District Court for the District of Colorado).

110. Expert Report (August 2017) on behalf of Appellant in the matter of *Patricia Ann Troiano (Appellant) v. Upper Burrell Township Zoning Hearing Board (Appellee)*, Court of Common Pleas of Westmoreland County, Pennsylvania, Civil Division.

111. Expert Report (October 2017), Supplemental Expert Report (October 2017), and Rebuttal Expert Report (November 2017) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

112. Declaration (December 2017) on behalf of the Environmental Integrity Project in the matter of permit issuance for ATI Flat Rolled Products Holdings, Breckenridge, PA to the Allegheny County Health Department.

113. Expert Report (Harm Phase) (January 2018), Rebuttal Expert Report (Harm Phase) (May 2018) and Supplemental Expert Report (Harm Phase) (April 2019) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).

114. Declaration (February 2018) on behalf of the Chesapeake Bay Foundation, et. al., in the matter of the Section 126 Petition filed by the state of Maryland in *State of Maryland v. Pruitt (Defendant)*, Civil Action No. JKB-17-2939 (Consolidated with No. JKB-17-2873) (US District Court for the District of Maryland).

115. Direct Pre-filed Testimony (March 2018) on behalf of the National Parks Conservation Association (NPCA) in the matter of *NPCA v State of Washington, Department of Ecology and BP West Coast Products, LLC*, PCHB No. 17-055 (Pollution Control Hearings Board for the State of Washington.

116. Expert Affidavit (April 2018) and Second Expert Affidavit (May 2018) on behalf of Petitioners in the matter of *Coosa River Basin Initiative and Sierra Club (Petitioners) v State of Georgia Environmental Protection Division, Georgia Department of Natural Resources (Respondent) and Georgia Power Company (Intervenor/Respondent)*, Docket Nos: 1825406-BNR-WW-57-Howells and 1826761-BNR-WW-57-Howells, Office of State Administrative Hearings, State of Georgia.

117. Direct Pre-filed Testimony and Affidavit (December 2018) on behalf of Sierra Club and Texas Campaign for the Environment (Appellants) in the contested case hearing before the Texas State Office of Administrative Hearings in Docket Nos. 582-18-4846, 582-18-4847 (Application of GCGV Asset Holding, LLC for Air Quality Permit Nos. 146425/PSDTX1518 and 146459/PSDTX1520 in San Patricio County, Texas).

118. Expert Report (February 2019) on behalf of Sierra Club in the State of Florida, Division of Administrative Hearings, Case No. 18-2124EPP, Tampa Electric Company Big Bend Unit 1 Modernization Project Power Plant Siting Application No. PA79-12-A2.

119. Declaration (March 2019) on behalf of Earthjustice in the matter of comments on the renewal of the Title V Federal Operating Permit for Valero Houston refinery.

120. Expert Report (March 2019) on behalf of Plaintiffs for Class Certification in the matter of *Resendez et al v Precision Castparts Corporation* in the Circuit Court for the State of Oregon, County of Multnomah, Case No. 16cv16164.

121. Expert Report (June 2019), Affidavit (July 2019) and Rebuttal Expert Report (September 2019) on behalf of Appellants relating to the NPDES permit for the Cheswick power plant in the matter of *Three Rivers Waterkeeper and Sierra Club (Appellants) v. State of Pennsylvania Department of Environmental Protection (Appellee) and NRG Power Midwest (Permittee)*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2018-088-R.

122. Affidavit/Expert Report (August 2019) relating to the appeal of air permits issued to PTTGCA on behalf of Appellants in the matter of *Sierra Club (Appellants) v. Craig Butler, Director, et. al., Ohio EPA (Appellees)* before the State of Ohio Environmental Review Appeals Commission (ERAC), Case Nos. ERAC-19-6988 through -6991.

123. Expert Report (October 2019) relating to the appeal of air permit (Plan Approval) on behalf of Appellants in the matter of *Clean Air Council and Environmental Integrity Project (Appellants) v. Commonwealth of Pennsylvania Department of Environmental Protection and Sunoco Partners Marketing and Terminals L.P.*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2018-057-L.

124. Expert Report (December 2019), Affidavit (March 2020), Supplemental Expert Report (July 2020), and Declaration (February 2021) on behalf of Earthjustice in the matter of *Objection to the Issuance of PSD/NSR and Title V permits for Riverview Energy Corporation*, Dale, Indiana, before the Indiana Office of Environmental Adjudication, Cause No. 19-A-J-5073.

125. Affidavit (December 2019) on behalf of Plaintiff-Intervenor (Surfrider Foundation) in the matter of *United States and the State of Indiana (Plaintiffs), Surfrider Foundation (Plaintiff-Intervenor), and City of Chicago (Plaintiff-Intervenor) v. United States Steel Corporation (Defendant),* Civil Action No. 2:18-cv-00127 (US District Court for the Northern District of Indiana, Hammond Division).

126. Declarations (January 2020, February 2020, May 2020, July 2020, and August 2020) and Pre-filed Testimony (April 2021) in support of Petitioner's Motion for Stay of PSCAA NOC Order of Approval No. 11386 in the matter of the *Puyallup Tribe of Indians v. Puget Sound Clean Air Agency (PSCAA) and Puget Sound Energy (PSE),* before the State of Washington Pollution Control Hearings Board, PCHB No. P19-088.

127. Expert Report (April 2020) on behalf of the plaintiff in the matter of Orion Engineered Carbons, GmbH (Plaintiff) vs. Evonik Operations, GmbH (formerly Evonik Degussa GmbH) (Respondent), before the German Arbitration Institute, Case No. DIS-SV-2019-00216.

128. Expert Independent Evaluation Report (June 2020) for *PacifiCorp's Decommissioning Costs Study Reports dated January 15, 2020 and March 13, 2020 relating to the closures of the Hunter, Huntington, Dave Johnston, Jim Bridger, Naughton, Wyodak, Hayden, and Colstrip (Units 3&4) plants*, prepared for the Oregon Public Utility Commission (Oregon PUC).

129. Direct Pre-filed Testimony (July 2020) on behalf of the Sierra Club in the matter of *the Application of the Ohio State University for a certificate of Environmental Compatibility and Public Need to Construct a Combined Heat and Power Facility in Franklin County, Ohio*, before the Ohio Power Siting Board, Case No. 19-1641-EL-BGN.

130. Expert Report (August 2020) and Rebuttal Expert Report (September 2020) on behalf of WildEarth Guardians (petitioners) in the matter of *the Appeals of the Air Quality Permit No. 7482-M1 Issued to 3 Bear Delaware Operating – NM LLC (EIB No. 20-21(A) and Registrations Nos. 8729, 8730, and 8733 under General Construction Permit for Oil and Gas Facilities (EIB No. 20-33 (A)*, before the State of New Mexico, Environmental Improvement Board.

131. Expert Report (July 2020) on the *Initial Economic Impact Analysis (EIA) for A Proposal To* Regulate *NOx Emissions from Natural Gas Fired Rich-Burn Natural Gas Reciprocating Internal Combustion Engines (RICE) Greater Than 100 Horsepower* prepared on behalf of Earthjustice and the National Parks Conservation Association in the matter of Regulation Number 7, Alternate Rules before the Colorado Air Quality Control Commission.

132. Expert Report (August 2020) and Supplemental Expert Report (February 2021) on the Potential Remedies to Avoid Adverse Thermal Impacts from the Merrimack Station on behalf of Plaintiffs in the matter of *Sierra Club Inc. and the* Conservation *Law Foundation (Plaintiffs) v. Granite Shore Power, LLC et. al., (Defendants)*, Civil Action No. 19-cv-216-JL (US District Court for the District of New Hampshire.)

133. Expert Report (August 2020) and Supplemental Expert Report (December 2020) on behalf of Plaintiffs in the matter of *PennEnvironment Inc., and Clean Air Council (Plaintiffs) and Allegheny County Health Department (Plaintiff-Intervenor) v. United States Steel Corporation (Defendant)*, Civil Action No. 2-19-cv-00484-MJH (US District Court for the Western District of Pennsylvania.)

134. Pre-filed Direct Testimony (October 2020) and Sur-rebuttal Testimony (November 2020) on behalf of petitioners (Ten Persons Group, including citizens, the Town of Braintree, the Town of Hingham, and the City of Quincy) in the matter of Algonquin Gas Transmission LLC, Weymouth MA, No. X266786 Air Quality Plan Approval, before the Commonwealth of Massachusetts, Department of Environmental Protection, the Office of Appeals and Dispute Resolution, OADR Docket Nos. 2019-008, 2019-009, 2019010, 2019-011, 2019-012 and 2019-013.

135. Expert Report (November 2020) on behalf of Protect PT in the matter of *Protect PT v. Commonwealth of Pennsylvania Department of Environmental Protection and Apex Energy (PA) LLC*, before the Commonwealth of Pennsylvania Environmental Hearing Board, Docket No. 2018-080-R (consolidated with 2019-101-R)(the "Drakulic Appeal").

136. Expert Report (December 2020) on behalf of Plaintiffs in the matter of *Sierra Club Inc. (Plaintiff) v. GenOn Power Midwest LP (Defendants)*, Civil Action No. 2-19-cv-01284-WSS (US District Court for the Western District of Pennsylvania.)

137. Pre-filed Testimony (January 2021) on behalf of the Plaintiffs (Shrimpers and Fishermen of the Rio Grande Valley represented by Texas RioGrande Legal Aid, Inc.) in the matter of the Appeal of Texas Commission on Environmental Quality (TCEQ) Permit Nos. 147681, PSDTX1522, GHGPSDTX172 for the Jupiter Brownsville Heavy Condensate Upgrader Facility, Cameron County, before the Texas State Office of Administrative Hearings, SOAH Docket No. 582-21-0111, TCEQ Docket No. 2020-1080-AIR.

138. Expert Report (June 2021) and Declarations (May 2021 and June 2021) on behalf of Plaintiffs in the matter of *Sierra Club (Plaintiff) v. Woodville Pellets, LLC (Defendant)*, Civil Action No. 9:20-cv-00178-MJT (US District Court for the Eastern District of Texas, Lufkin Division.)

139. Declaration (July 2021) on behalf of Plaintiffs in the matter of *Stephanie Mackey and Nick Migliore, on behalf of themselves and all others similarly situated (Plaintiffs) v. Chemtool Inc. and Lubrizol Corporation (Defendants)*, Case No. 2021-L-0000165, State of Illinois, Circuit Court of the 17th Judicial Circuit, Winnebago County.

140. Expert Report (April 2021) and Sur-Rebuttal Report (June 2021) on behalf of the Plaintiffs in the matter of *Modern Holdings, LLC, et al. (Plaintiffs) v. Corning Inc., et al. (Defendants)*, Civil Action No. 5:13-cv-00405-GFVT, (US District Court for the Eastern District of Kentucky, Central Division at Lexington).

141. Expert Witness Disclosure (June 2021) on behalf of the Plaintiffs in the matter of *Jay Burdick, et. al., (Plaintiffs) v. Tanoga Inc. (d/b/a Taconic) (Defendant)*, Index No. 253835, (State of New York Supreme Court, County of Rensselaer).

142. Expert Report (June 2021) on behalf of Appellants in the matter of *PennEnvironment and Earthworks (Appellants) v. Commonwealth of Pennsylvania Department of Environmental Protection (Appellee) and MarkWest Liberty Midstream and resource, LLC (Permittee)*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2020-002-R.

143. Expert Reports (March 2021 and May 2021) regarding the Aries Newark LLC Sludge Processing Facility, Application No. CPB 20-74, Central Planning Board, City of Newark, New Jersey.

144. Expert Report (April 2021) for *Charles Johnson Jr. (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant),* Civil Action No. 2:20-CV-01329. (US District Court for the Eastern District of Louisiana, New Orleans Division).

145. Expert Report (April 2021) for *Floyd Ruffin (Plaintiff), v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 2:20-cv-00334-CJB-JCW (US District Court for the Eastern District of Louisiana, New Orleans Division).

146. Expert Report (May 2021) for *Clifford Osmer (Plaintiff) v. BP Exploration and Production Inc., et. al., (Defendants)* related to No. 2:19-CV-10331 (US District Court for the Eastern District of Louisiana, New Orleans Division).

147. Expert Report (June 2021) for *Antonia Saavedra-Vargas (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 2:18-CV-11461 (US District Court for the Eastern District of Louisiana, New Orleans Division).

148. Affidavit (June 2021) for Lourdes Rubi in the matter of *Lourdes Rubi (Plaintiff) v. BP Exploration and Production Inc., et. al., (Defendants)*, related to 12-968 BELO in MDL No. 2179 (US District Court for the Eastern District of Louisiana, New Orleans Division).

149. Expert Report (May 2021) for *James Noel (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant),* Civil Action No. 1:19-CV-00694 (US District Court for the Southern District of Alabama, Mobile Division).

150. Expert Report (June 2021) for *Wallace Smitht (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 2:19-CV-12880 (US District Court for the Eastern District of Louisiana, New Orleans Division).

C. Occasions where Dr. Sahu has provided oral testimony in depositions, at trial or in similar proceedings include the following:

151. Deposition on behalf of Rocky Mountain Steel Mills, Inc. located in Pueblo, Colorado – dealing with the manufacture of steel in mini-mills including methods of air pollution control and BACT in steel mini-mills and opacity issues at this steel mini-mill.

152. Trial Testimony (February 2002) on behalf of Rocky Mountain Steel Mills, Inc. in Denver District Court.

153. Trial Testimony (February 2003) on behalf of the United States in the Ohio Edison NSR Cases, *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (Southern District of Ohio).

154. Trial Testimony (June 2003) on behalf of the United States in the Illinois Power NSR Case, *United States v. Illinois Power Co., et al.*, 99-833-MJR (Southern District of Illinois).

155. Deposition (10/20/2005) on behalf of the United States in connection with the Cinergy NSR Case. *United States, et* al. *v. Cinergy Corp., et al.*, IP 99-1693-C-M/S (Southern District of Indiana).

156. Oral Testimony (August 2006) on behalf of the Appalachian Center for the Economy and the Environment re. the Western Greenbrier plant, WV before the West Virginia DEP.

157. Oral Testimony (May 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) re. the Thompson River Cogeneration plant before the Montana Board of Environmental Review.

158. Oral Testimony (October 2007) on behalf of the Sierra Club re. the Sevier Power Plant before the Utah Air Quality Board.

159. Oral Testimony (August 2008) on behalf of the Sierra Club and Clean Water re. Big Stone Unit II before the South Dakota Board of Minerals and the Environment.

160. Oral Testimony (February 2009) on behalf of the Sierra Club and the Southern Environmental Law Center re. Santee Cooper Pee Dee units before the South Carolina Board of Health and Environmental Control.

161. Oral Testimony (February 2009) on behalf of the Sierra Club and the Environmental Integrity Project re. NRG Limestone Unit 3 before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

162. Deposition (July 2009) on behalf of MTD Products, Inc., in the matter of *Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al.*

163. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Coleto Creek coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

164. Deposition (October 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

165. Deposition (October 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.

166. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Tenaska coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH). (April 2010).

167. Oral Testimony (November 2009) on behalf of the Environmental Defense Fund re. the Las Brisas Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

168. Deposition (December 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

169. Oral Testimony (February 2010) on behalf of the Environmental Defense Fund re. the White Stallion Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

170. Deposition (June 2010) on behalf of the United States in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).

171. Trial Testimony (September 2010) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, State of Maryland, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case in US District Court in the Western District of Pennsylvania. *Plaintiffs v. Allegheny Energy Inc., et al.,* 2:05cv0885 (Western District of Pennsylvania).

172. Oral Direct and Rebuttal Testimony (September 2010) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).

173. Oral Testimony (September 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions,* No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.

174. Oral Testimony (October 2010) on behalf of the Environmental Defense Fund re. the Las Brisas Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

175. Oral Testimony (November 2010) regarding BART for PSCo Hayden, CSU Martin Drake units before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.

176. Oral Testimony (December 2010) regarding BART for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.

177. Deposition (December 2010) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).

178. Deposition (February 2011 and January 2012) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (D. Colo.).

179. Oral Testimony (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).

180. Deposition (August 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (District of Colorado).

181. Deposition (July 2011) and Oral Testimony at Hearing (February 2012) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.

182. Oral Testimony at Hearing (March 2012) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).

183. Oral Testimony at Hearing (April 2012) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).

184. Oral Testimony at Hearing (November 2012) on behalf of Clean Wisconsin in the matter of Application of Wisconsin Public Service Corporation for Authority to Construct and Place in Operation a New Multi-Pollutant Control Technology System (ReACT) for Unit 3 of the Weston Generating Station, before the Public Service Commission of Wisconsin, Docket No. 6690-CE-197.

185. Deposition (March 2013) in the matter of various Environmental Petitioners v. North Carolina DENR/DAQ and Carolinas Cement Company, before the Office of Administrative Hearings, State of North Carolina.

186. Deposition (August 2013) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).

187. Deposition (August 2013) on behalf of the Sierra Club in connection with the Luminant Martin Lake Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 5:10-cv-0156-MHS-CMC (Eastern District of Texas, Texarkana Division).

188. Deposition (February 2014) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).

189. Trial Testimony (February 2014) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.,* Civil Action No. 4:10-cv-4969 (Southern District of Texas, Houston Division).

190. Trial Testimony (February 2014) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).

191. Deposition (June 2014) and Trial (August 2014) on behalf of ECM Biofilms in the matter of the *US Federal Trade Commission (FTC) v. ECM Biofilms* (FTC Docket #9358).

192. Deposition (February 2015) on behalf of Plaintiffs in the matter of *Sierra Club and Montana Environmental Information Center (Plaintiffs) v. PPL Montana LLC, Avista Corporation, Puget Sound Energy, Portland General Electric Company, Northwestern Corporation, and Pacificorp (Defendants)*, Civil Action No. CV 13-32-BLG-DLC-JCL (US District Court for the District of Montana, Billings Division).

193. Oral Testimony at Hearing (April 2015) on behalf of Niagara County, the Town of Lewiston, and the Villages of Lewiston and Youngstown in the matter of CWM Chemical Services, LLC New York State Department of Environmental Conservation (NYSDEC) Permit Application Nos.: 9-2934-00022/00225, 9-2934-00022/00231, 9-2934-00022/00232, and 9-2934-00022/00249 (pending).

194. Deposition (August 2015) on behalf of Plaintiff in the matter of *Conservation Law Foundation (Plaintiff) v. Broadrock Gas Services LLC, Rhode Island LFG GENCO LLC, and Rhode Island Resource Recovery*

Corporation (Defendants), Civil Action No. 1:13-cv-00777-M-PAS (US District Court for the District of Rhode Island).

195. Testimony at Hearing (August 2015) on behalf of the Sierra Club in the matter of *Amendments to 35 Illinois Administrative Code Parts 214, 217, and 225* before the Illinois Pollution Control Board, R15-21.

196. Deposition (May 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., (Plaintiffs) v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

197. Trial Testimony (October 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., (Plaintiffs) v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

198. Deposition (April 2016) on behalf of the Plaintiffs in *UNatural Resources Defense Council, Respiratory Health Association, and Sierra Club (Plaintiffs) v. Illinois Power Resources LLC and Illinois Power Resources Generation LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (Central District of Illinois, Peoria Division).

199. Trial Testimony at Hearing (July 2016) in the matter of Tesoro Savage LLC Vancouver Energy Distribution Terminal, Case No. 15-001 before the State of Washington Energy Facility Site Evaluation Council.

200. Trial Testimony (December 2016) on behalf of the challengers in the matter of the Delaware Riverkeeper Network, Clean Air Council, et. al., vs. Commonwealth of Pennsylvania Department of Environmental Protection and R. E. Gas Development LLC regarding the Geyer well site before the Pennsylvania Environmental Hearing Board.

201. Trial Testimony (July-August 2016) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).

202. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Huntley and Huntley Poseidon Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

203. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Backus Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

204. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Drakulic Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

205. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Deutsch Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

206. Deposition Testimony (July 2017) on behalf of Plaintiffs in the matter of *Casey Voight and Julie Voight v Coyote Creek Mining Company LLC (Defendant)* Civil Action No. 1:15-CV-00109 (US District Court for the District of North Dakota, Western Division).

207. Deposition Testimony (November 2017) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

208. Deposition Testimony (December 2017) on behalf of Plaintiff in the matter of *Wildearth Guardians (Plaintiff) v Colorado Springs Utility Board (Defendant)* Civil Action No. 1:15-cv-00357-CMA-CBS (US District Court for the District of Colorado).

209. Deposition Testimony (January 2018) in the matter of National Parks Conservation Association (NPCA) v. State of Washington Department of Ecology and British Petroleum (BP) before the Washington Pollution Control Hearing Board, Case No. 17-055.

210. Trial Testimony (January 2018) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

211. Trial Testimony (April 2018) on behalf of the National Parks Conservation Association (NPCA) in the matter of NPCA v State of Washington, Department of Ecology and BP West Coast Products, LLC, PCHB No. 17-055 (Pollution Control Hearings Board for the State of Washington.

212. Deposition (June 2018) (harm Phase) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).

213. Trial Testimony (July 2018) on behalf of Petitioners in the matter of *Coosa River Basin Initiative and Sierra Club (Petitioners) v State of Georgia Environmental Protection Division, Georgia Department of Natural Resources (Respondent) and Georgia Power Company (Intervenor/Respondent)*, Docket Nos: 1825406-BNR-WW-57-Howells and 1826761-BNR-WW-57-Howells, Office of State Administrative Hearings, State of Georgia.

214. Deposition (January 2019) and Trial Testimony (January 2019) on behalf of Sierra Club and Texas Campaign for the Environment (Appellants) in the contested case hearing before the Texas State Office of Administrative Hearings in Docket Nos. 582-18-4846, 582-18-4847 (Application of GCGV Asset Holding, LLC for Air Quality Permit Nos. 146425/PSDTX1518 and 146459/PSDTX1520 in San Patricio County, Texas).

215. Deposition (February 2019) and Trial Testimony (March 2019) on behalf of Sierra Club in the State of Florida, Division of Administrative Hearings, Case No. 18-2124EPP, Tampa Electric Company Big Bend Unit 1 Modernization Project Power Plant Siting Application No. PA79-12-A2.

216. Deposition (June 2019) relating to the appeal of air permits issued to PTTGCA on behalf of Appellants in the matter of *Sierra Club (Appellants) v. Craig Butler, Director, et. al., Ohio EPA (Appellees)* before the State of Ohio Environmental Review Appeals Commission (ERAC), Case Nos. ERAC-19-6988 through -6991.

217. Deposition (September 2019) on behalf of Appellants relating to the NPDES permit for the Cheswick power plant in the matter of *Three Rivers Waterkeeper and Sierra Club (Appellants) v. State of Pennsylvania Department of Environmental Protection (Appellee) and NRG Power Midwest (Permittee)*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2018-088-R.

218. Deposition (December 2019) on behalf of the Plaintiffs in the matter of David Kovac, individually and on behalf of wrongful death class of Irene Kovac v. BP Corporation North America Inc., Circuit Court of Jackson County, Missouri (Independence), Case No. 1816-CV12417.

219. Deposition (February 2020, virtual) and testimony at Hearing (August 2020, virtual) on behalf of Earthjustice in the matter of *Objection to the Issuance of PSD/NSR and Title V permits for Riverview Energy Corporation*, Dale, Indiana, before the Indiana Office of Environmental Adjudication, Cause No. 19-A-J-5073.

220. Hearing (July 14-15, 2020, virtual) on behalf of the Sierra Club in the matter of *the Application of the Ohio State University for a certificate of Environmental Compatibility and Public Need to Construct a Combined Heat and Power Facility in Franklin County, Ohio*, before the Ohio Power Siting Board, Case No. 19-1641-EL-BGN.

221. Hearing (September 2020, virtual) on behalf of WildEarth Guardians (petitioners) in the matter of *the Appeals of the Air Quality Permit No. 7482-M1 Issued to 3 Bear Delaware* Operating – *NM LLC (EIB No. 20-21(A) and Registrations Nos. 8729, 8730, and 8733 under General Construction Permit for Oil and Gas Facilities (EIB No. 20-33 (A)*, before the State of New Mexico, Environmental Improvement Board.

222. Deposition (December 2020, March 4-5, 2021, all virtual) and Hearing (April 2021, virtual) in support of Petitioner's Motion for Stay of PSCAA NOC Order of Approval No. 11386 in the matter of the *Puyallup Tribe of Indians v. Puget Sound Clean Air Agency (PSCAA) and Puget Sound Energy (PSE),* before the State of Washington Pollution Control Hearings Board, PCHB No. P19-088.

223. Hearing (September 2020, virtual) on the *Initial Economic Impact Analysis (EIA) for A Proposal To* Regulate *NOx Emissions from Natural Gas Fired Rich-Burn Natural Gas Reciprocating Internal Combustion Engines (RICE) Greater Than 100 Horsepower* prepared on behalf of Earthjustice and the National Parks Conservation Association in the matter of Regulation Number 7, Alternate Rules before the Colorado Air Quality Control Commission.

224. Deposition (December 2020, virtual and Hearing February 2021, virtual) on behalf of the Plaintiffs (Shrimpers and Fishermen of the Rio Grande Valley represented by Texas RioGrande Legal Aid, Inc.) in the matter of the Appeal of Texas Commission on Environmental Quality (TCEQ) Permit Nos. 147681, PSDTX1522, GHGPSDTX172 for the Jupiter Brownsville Heavy Condensate Upgrader Facility, Cameron County, before the Texas State Office of Administrative Hearings, SOAH Docket No. 582-21-0111, TCEQ Docket No. 2020-1080-AIR.

225. Deposition (January 2021, virtual) on behalf of Plaintiffs in the matter of *PennEnvironment Inc., and Clean Air Council (Plaintiffs) and Allegheny County Health Department (Plaintiff-Intervenor) v. United States Steel Corporation (Defendant)*, Civil Action No. 2-19-cv-00484-MJH (US District Court for the Western District of Pennsylvania.)

226. Deposition (February 2021, virtual) on behalf of Plaintiffs in the matter of *Sierra Club Inc. (Plaintiff) v. GenOn Power Midwest LP (*Defendants*)*, Civil Action No. 2-19-cv-01284-WSS (US District Court for the Western District of Pennsylvania.)

227. Deposition (April 2021, virtual) on the Potential Remedies to Avoid Adverse Thermal Impacts from the Merrimack Station on behalf of Plaintiffs in the matter of *Sierra Club Inc. and the* Conservation *Law Foundation (Plaintiffs) v. Granite Shore Power, LLC et. al., (Defendants)*, Civil Action No. 19-cv-216-JL (US District Court for the District of New Hampshire.)

228. Deposition (June 2021, virtual) on behalf of Plaintiffs in the matter of *Sierra Club (Plaintiff) v. Woodville Pellets, LLC (Defendant)*, Civil Action No. 9:20-cv-00178-MJT (US District Court for the Eastern District of Texas, Lufkin Division).

229. Deposition (June 2021, virtual) on behalf of the Plaintiffs in the matter of *Modern Holdings, LLC, et al. (Plaintiffs) v. Corning Inc., et al. (Defendants)*, Civil Action No. 5:13-cv-00405-GFVT, (US District Court for the Eastern District of Kentucky, Central Division at Lexington).

230. Testimony (June 2021, virtual) regarding the Aries Newark LLC Sludge Processing Facility, Application No. CPB 20-74, Central Planning Board, City of Newark, New Jersey.

Exhibit C

Plaquemines LNG

Plaquemines Parish, Louisiana

Evaluation of Compliance with the 1-hour NAAQS for NO_2

May 25, 2022

Conducted by:

Steven Klafka, P.E., BCEE

Wingra Engineering, S.C.

Madison, Wisconsin

1. Introduction

Wingra Engineering, S.C. was hired by the Sierra Club to conduct an air modeling impact analysis to determine if large emission sources were causing exceedences of the 1-hour nitrogen dioxide (NO_2) national ambient air quality standard (NAAQS) in Plaquemines Parish, Louisiana. This document describes the procedures and results for the evaluation of 619 individual sources of NO_2 located in Plaquemines Parish and adjacent parishes in Louisiana.

The dispersion modeling analysis predicted ambient air concentrations for comparison with the 1-hour NO_2 NAAQS. The modeling was performed using the most recent version of AERMOD, AERMET, and AERMINUTE, with data provided to the Sierra Club by regulatory air agencies and through other publicly-available sources. The analysis was conducted following all available USEPA guidance for evaluating source impacts on attainment of the 1-hour NO_2 NAAQS via aerial dispersion modeling. This guidance included: the AERMOD Implementation Guide; modeling guidance promulgated by USEPA in Appendix W to 40 CFR Part 51; USEPA's September 30, 2014 memorandum, Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard [1], USEPA's March 1, 2011 memorandum, Additional Clarification Regarding Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS[2], and USEPA's June 28, 2010 memorandum, Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS[3].

To comply with the Prevention of Significant Deterioration (PSD) requirements of the Clean Air Act, Trinity Consultants (TC) prepared a PSD permit application and conducted an air quality modeling study on behalf of the Plaquemines LNG liquefied natural gas facility in Plaquemines Parish, Louisiana.[4] The PSD permit application was submitted to the Louisiana Department of Environmental Quality (DEQ) by Venture Global Plaquemines LNG, LLC. The enclosed modeling analysis updates the 2020 evaluation, and provides additional comments.

TC conducted an analysis to determine if regional sources, including the proposed Plaquemines LNG project, complied with the 1-hour NAAQS for NO_2. The results of the 1-hour NO_2 cumulative modeling results were presented in Table 5.3 of their report. The analysis predicted exceedances of the NAAQS. TC concluded that the Plaquemines LNG project did not contribute significantly to the predicted NAAQS exceedences, so conducted no further evaluation of the predicted NAAQS exceedences.

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[1] https://www.epa.gov/sites/production/files/2020-10/documents/no2_clarification_memo-20140930.pdf
[2] https://www.epa.gov/sites/production/files/2020-10/documents/additional_clarifications_appendixw_hourly-no2-naaqs_final_03-01-2011.pdf
[3] https://www.epa.gov/sites/production/files/2020-10/documents/clarificationmemo_appendixw_hourly-no2-naaqs_final_06-28-2010.pdf
[4] Trinity Consultants, Title V Permit Significant Modification and PSD Permit Modification Application for Venture Global Plaquemines LNG, LLC and Venture Global Gator Express, LLC, January 27, 2020.

It should be noted that the TC analysis for NAAQS compliance only considered receptor locations where the Plaquemines project was predicted to have a significant impact. Therefore, all locations where violations of the NAAQS may occur in the surrounding region were not identified.

The enclosed modeling analysis used the same input files as the TC analysis and were obtained from DEQ. It utilized the same information as accepted by DEQ for the PSD permit application for the Plaquemines LNG project. Since the TC modeling analysis was conducted in 2020, the most current versions of the AERMOD modeling system were used for the updated analysis.

A summary of modeling procedures is as follows:

1. Latest version of AERMOD (v21112) with the regulatory default option in the rural mode;

2. Surface meteorological data collected at the National Weather Service (NWS) station at the New Orleans International Airport (Station No. 12916) for the period 2019-2021 to generate AERMOD-ready meteorological data. Upper air meteorological data were obtained from the Slidell, Louisiana station. These data were processed using the most recent version of AERMET (v21112);

3. A fixed background NO_2 concentration was obtained from the ambient monitoring station (Monitor ID 22-051-1001) located in Kenner, Louisiana.

4. Tier-2 Ambient Ratio Method (ARM2) method to predict the conversion of NO_x to NO_2; and,

5. Regional source inventory of 619 sources of NO_x emissions including the proposed Plaquemines LNG project.

The purpose of this new analysis was to: 1) determine the full extent of NAAQS exceedences in Plaquemines Parish as well as adjacent parishes and counties, and 2) evaluate the suitability of existing air quality monitoring stations. For this reason, two changes were made to the original modeling files:

1) the modeling domain was extended to the full 50-kilometer distance approved by USEPA for use by AERMOD. This new receptor grid was centered Plaquemines LNG facility.

2) the TC modeling analysis removed approximately 1,200 acres of land around Plaquemines LNG from consideration for compliance with the NAAQS. While this land may be owned by the company, there was no description of a fence or other measures that would be employed to preclude public access to the property. Therefore, the updated modeling analysis included receptors on this property.

2. Modeling Results

2.1 1-hour NO_2 SIL and NAAQS

The significant impact level or SIL for NO_2 for the 1-hour averaging period is 7.5 $\mu g/m^3$. This is based on the average of the maximum 1-hour concentrations for each year using five years of meteorology.

The 1-hour average NO_2 NAAQS takes the form of a three-year average of the 98th percentile of the annual distribution of daily maximum 1-hour concentrations, which cannot exceed 100 parts per billion (ppb).[5] Compliance with this standard was verified using USEPA's AERMOD air dispersion model, which produces air concentrations in units of $\mu g/m^3$. The 1-hour NO_2 NAAQS of 100 ppb equals 188 $\mu g/m^3$, and this is the value used for determining whether modeled impacts exceed the NAAQS. The 98th percentile of the annual distribution of daily maximum 1-hour concentrations corresponds to the eighth-highest value at each receptor for a given year.

2.2 Plaquemines LNG Facility and Comparison with the Significant Impact Level

The 1-hour average SIL for NO_2 is 7.5 $\mu g/m^3$. If emissions from the Plaquemines LNG facility are predicted to exceed the SIL, the facility is obligated to determine if its emissions combined with those from other regional sources comply with the NAAQS for NO_2. The 2020 analysis by TC determined that the Plaquemines LNG facility exceeded the SIL so a NAAQS compliance analysis was conducted.

The modeling for comparison with the SIL was updated for the enclosed analysis. The Plaquemines LNG facility was predicted to have a maximum 1-hour average impact of 20.2 $\mu g/m^3$. Since this exceeds the SIL, a NAAQS compliance analysis would be required.

Figure 1 shows the extent in which the Plaquemines LNG facility exceeds the 1-hour SIL of 7.5 $\mu g/m^3$ for NO_2. The SIL was predicted to be exceeded in Acadiana, Jefferson, Lafourche, Plaquemines, and St. Bernard Parishes. The maximum distance to a SIL exceedance is 16 km. Boundaries of parishes in Louisiana are shown with black lines.

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[5] USEPA, Additional Clarification Regarding Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS, March 2, 2011.

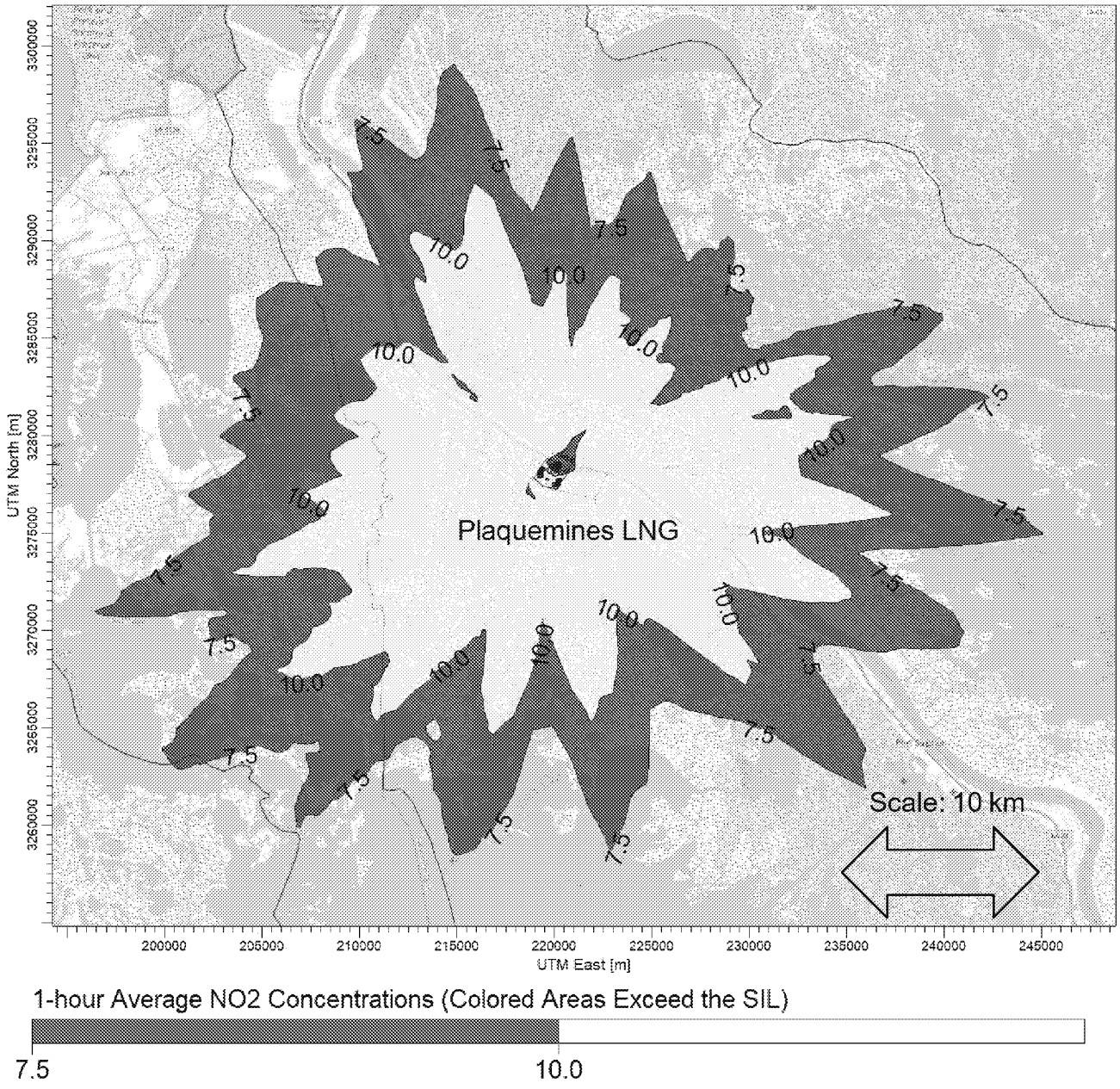

Figure 1 – Exceedences of 1-hour Average NO_2 SIL by Plaquemines LNG

Table 1 provides the highest Plaquemines LNG concentrations which exceed the 1-hour SIL. These are the 5-year average of the 1-hour maximum concentrations for unique locations and hours.

Table 1 - Plaquemines LNG Maximum Impacts Exceeding 1-hour Average SIL of 7.5 µg/m³

X	Y	Average	NO_2 Concentration (µg/m³)
217879	3279044	1ST	20.2
217579	3275244	1ST	20.2
217979	3278944	1ST	20.2
217479	3275144	1ST	20.2
217779	3279044	1ST	20.2
217679	3275344	1ST	20.1
217579	3275144	1ST	20.1
217879	3278944	1ST	20.1
217579	3279244	1ST	20.1
217479	3275044	1ST	20.1

2.3 Compliance with the 1-hour NO_2 NAAQS

The TC modeling analysis predicted a maximum impact of 271.2 µg/m³ including background. This exceeded the NAAQS of 188 µg/m³.

After expanding the size of the receptor grid and number of receptors, the updated modeling analysis predicted a maximum impact of 3,692.8 µg/m³ including background. This again exceeded the NAAQS of 188 µg/m³. The greatest length of the area exceeding the NAAQS was 49 kilometers, the full extent of the modeling domain. NAAQS exceedences were predicted to occur in Acadiana, Jefferson, Lafourche, Plaquemines, and St. Bernard Parishes in Louisiana.

Figure 2 shows the full extent of predicted exceedances of the 1-hour NAAQS for NO_2. Boundaries of parishes in Louisiana are shown with black lines.

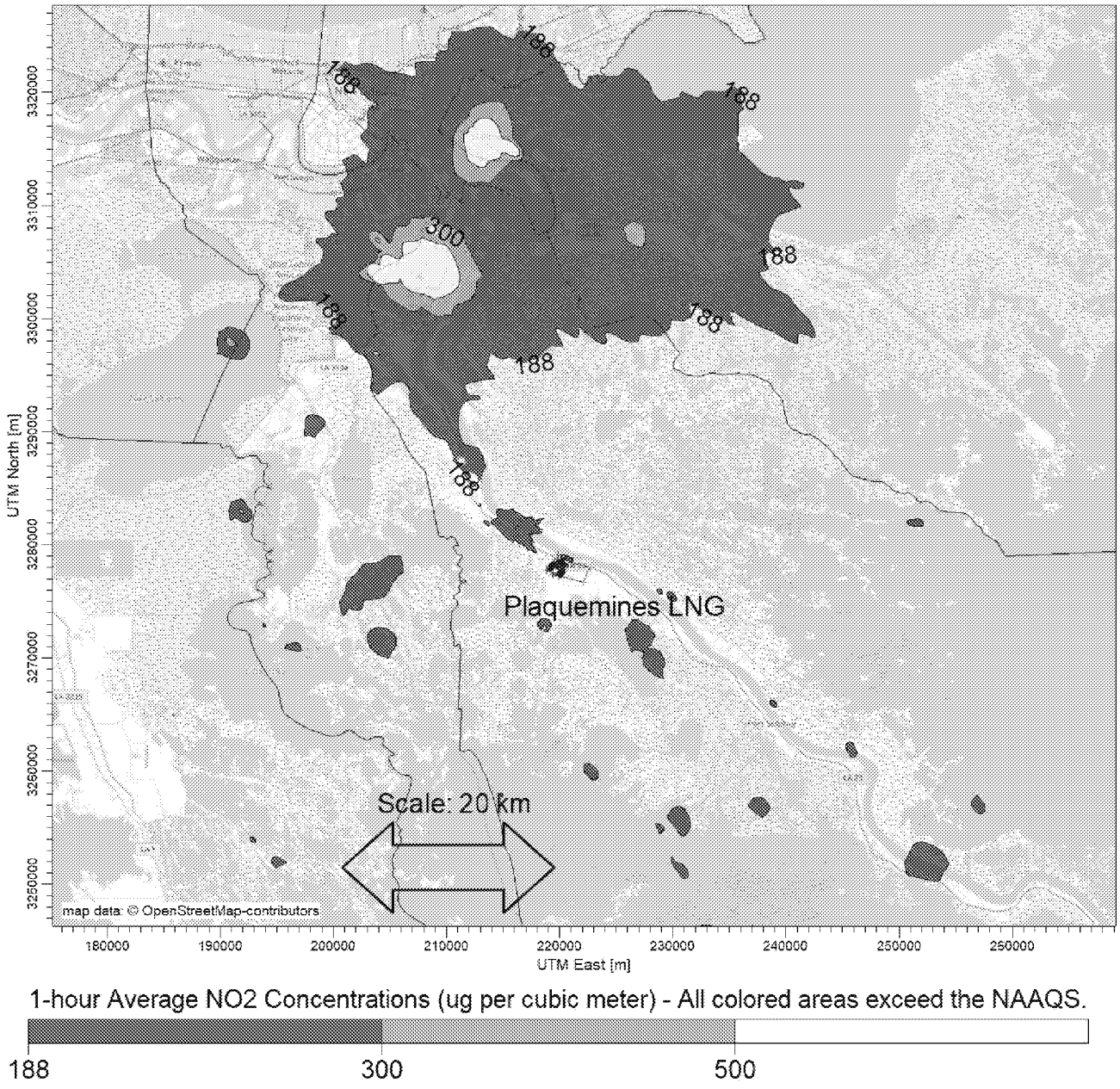

Figure 2 – NAAQS Exceedences by Plaquemines LNG and Regional Sources

2.4 Comparison of Modeling Results and Ambient Monitoring Sites

In the modeling domain there are two existing ambient monitoring sites for NO_2. These are located in New Orleans metropolitan area north of the areas where exceedences of the NAAQS are predicted. These are the Kenner Site (Site ID #220511001) and I-610 Site (Site ID #220710021).

Figure 3 shows the location of the two existing monitoring sites for NO_2 in relation to the areas where the updated modeling study predicted exceedences of the 1-hour NAAQS. Existing monitoring sites for NO_2 are not located in the areas with predicted exceedences of the NAAQS. Additional monitors are needed to determine compliance with the NAAQS in these areas.

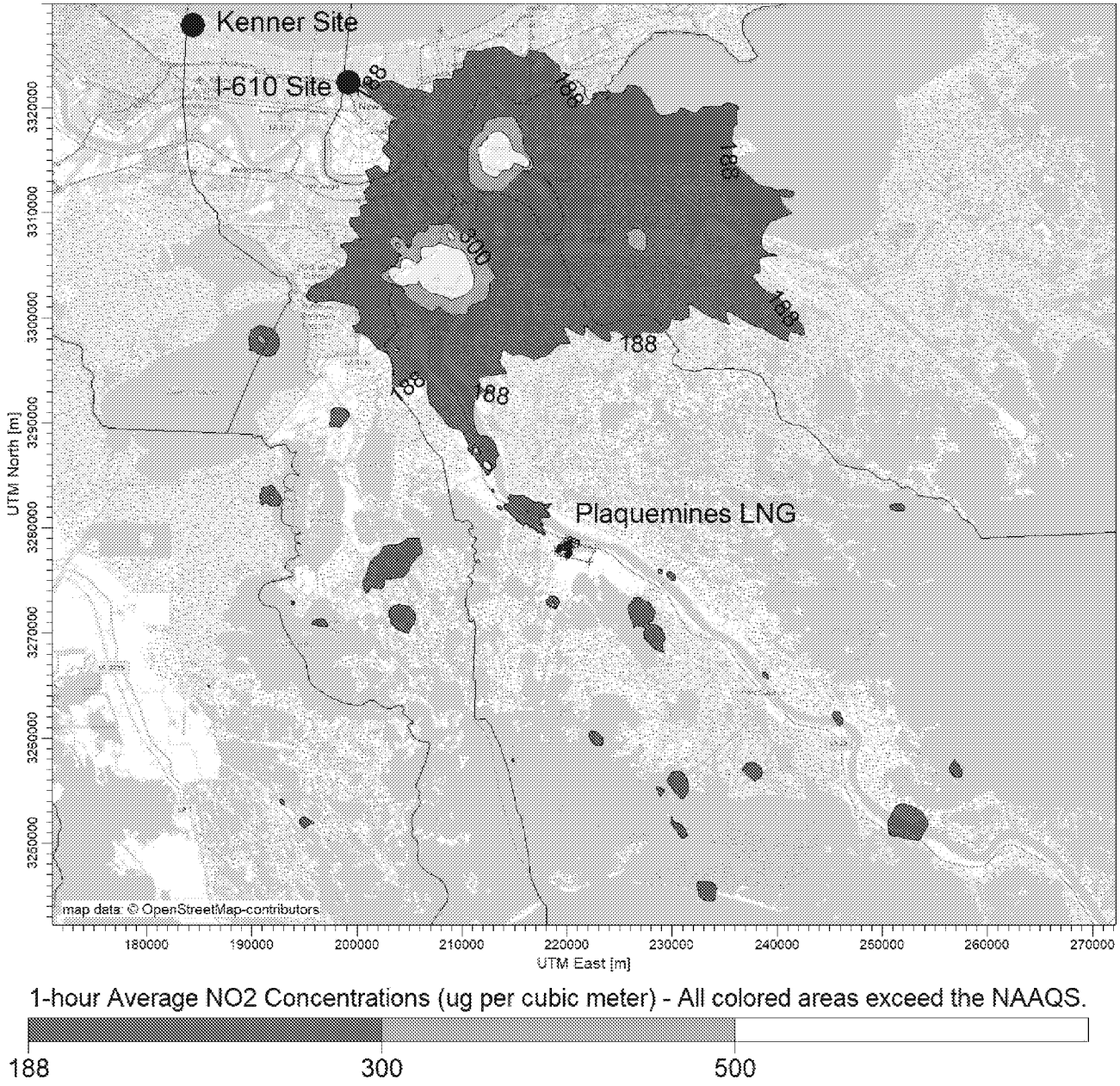

Figure 3 – NO_2 Monitor Locations and Predicted NAAQS Exceedences

Figure 4 shows the location of the two existing monitoring sites for NO2 in relation to the areas where the updated modeling study predicted exceedences of the 1-hour NAAQS. To evaluate the environmental justice (EJ) impacts of the NAAQS exceedences, the base map for this figure provides the percent people of color in each census tract. The gradations of people of color in the population of each census tract are 0-20% (lightest shade), 20-40%, 40-60%, 60-80%, 80-100% (darkest shade). Existing monitor sites are not located in census tracts with a higher percentage of people of color. Additional monitors are needed to determine compliance with the NAAQS in these areas and evaluate EJ impacts.

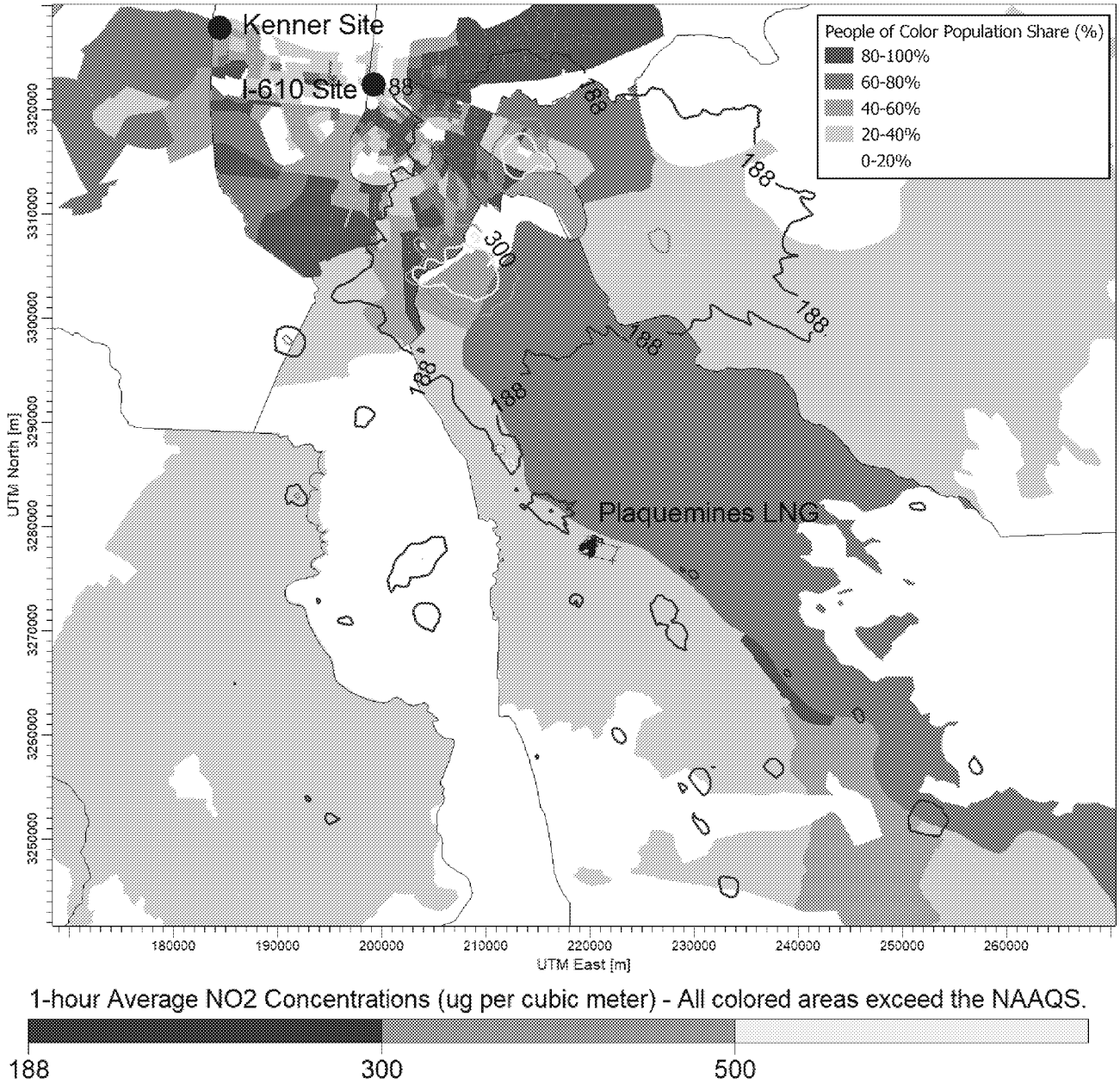

Figure 4 – NO_2 Monitor Locations, Predicted NAAQS Exceedences & People of Color

Figure 5 shows the location of the two existing monitoring sites for NO_2 in relation to the areas where the updated modeling study predicted exceedences of the 1-hour NAAQS. To evaluate the EJ impacts of the NAAQS exceedences, the base map for this figure provides the income levels of residents in each census tract in increments of $25,000 per year. Existing monitor sites are located in higher income census tracts but not those with low-income households. Additional monitors are needed to determine compliance with the NAAQS in these areas and evaluate EJ impacts.

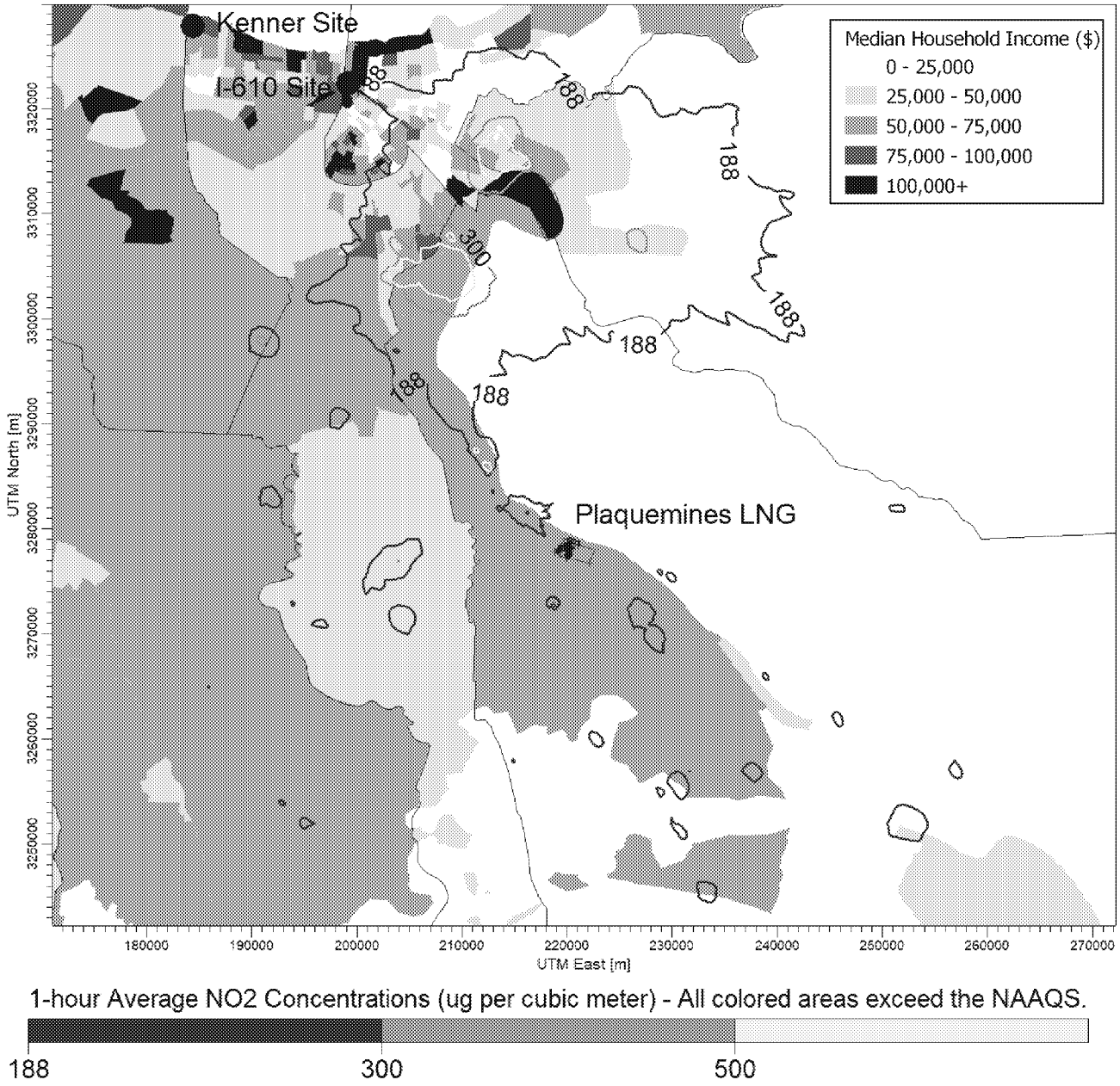

Figure 5 - NO_2 Monitor Locations, Predicted NAAQS Exceedences & Household Income Levels

2.5 Conservative Modeling Assumptions

The modeling results presented in the report may under-estimate NO_2 concentrations for the following reasons:

1) The inventory of regional emission sources included substitutions for rates and stack parameters if these were missing or considered inappropriate. These substitutions may underestimate the air quality impact of these sources.

2) The 50-kilometer receptor grid was centered on the Plaquemines LNG facility. Emission sources are located throughout this grid and may individually be culpable for NAAQS exceedences. The receptor grid would need to be centered on each source to fully determine if the source is capable of exceeding the NAAQS.

3) The downwash effect of buildings and structures was evaluated only for the proposed Plaquemines LNG project. It was not considered for the other regional sources. The consideration of downwash may increase in the predicted impacts of the regional sources.

3. Modeling Methodology

3.1 Air Dispersion Model

The modeling analysis used the most recent version of USEPA's AERMOD program, v. 21112. AERMOD, as available from the Support Center for Regulatory Atmospheric Modeling (SCRAM) website, was used in conjunction with a third-party modeling software program, *AERMOD View*, sold by Lakes Environmental Software.

3.2 Control Options

The AERMOD model was run with the following control options:

- 1-hour average air concentrations
- Regulatory defaults

In its 2020 modeling report, TC did not conduct an evaluation to determine if the modeled facility was located in a rural or urban setting using USEPA's methodology outlined in Section 7.2.3 of the Guideline on Air Quality Models.[6] For urban sources, the URBANOPT option is used in conjunction with the urban population from an appropriate nearby city and a default surface roughness of 1.0 meter. Methods described in Section 4.1 were used to determine whether rural or urban dispersion coefficients were appropriate for the modeling analysis.

3.3 Output Options

The AERMOD analysis was based on recent meteorological data. The modeling analysis was conducted using sequential meteorological data from the 2019-21 period. Consistent with USEPA's guidance for evaluation compliance with the NO_2 NAAQS, AERMOD was used to provide a table of eighth-high 1-hour NO_2 impacts concentrations consistent with the form of the 1-hour SO_2 NAAQS.

Please refer to Section 2.0 for the modeling results.

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[6] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005.

4. Model Inputs

4.1 Geographical Inputs

The air dispersion modeling analysis used a coordinate system for identifying the geographical location of emission sources and receptors. These geographical locations are used to determine local characteristics (such as land use and elevation), and also to ascertain source to receptor distances and relationships.

The Universal Transverse Mercator (UTM) NAD83 coordinate system was used for identifying the easting (x) and northing (y) coordinates of the modeled sources and receptors. Plaquemines LNG and Plaquemines Parish are located in UTM Zone 16.

The facility was evaluated to determine if it should be modeled using the rural or urban dispersion coefficient option in AERMOD. A GIS was used to determine whether rural or urban dispersion coefficients apply to a site. Land use within a three-kilometer radius circle surrounding the facility was considered. USEPA guidance states that urban dispersion coefficients are used if more than 50% of the area within 3 kilometers has urban land uses. Otherwise, rural dispersion coefficients are appropriate.[7] It was determined that land use around the Plaquemine LNG facility was 3.4% urban which included low, medium and high intensity development land use categories. Therefore, rural dispersion coefficients were used for the updated modeling analysis.

In its 2020 modeling report, TC did not evaluate the use of urban vs rural dispersion coefficients.

4.2 Emission Rates and Source Parameters

The emissions and stack parameters for the 619 sources included in the modeling analysis are summarized in the 2020 modeling report submitted by TC to DEQ. Procedures for assembling the regional source inventory, as well as all modeling procedures, were described in the 2020 modeling report submitted by TC to DEQ.

4.3 Downwash

The downwash effect of buildings and structures was considered for only the proposed Plaquemines LNG project. Downwash effects for other regional sources was not considered.

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[7] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005, Section 7.2.3.

4.4 Receptors

Three receptor grids were employed:

1. A 100-meter Cartesian receptor grid centered on Plaquemines LNG and extending out 5 kilometers.
2. A 500-meter Cartesian receptor grid centered on Plaquemines LNG and extending out 10 kilometers.
3. A 1,000-meter Cartesian receptor grid centered on Plaquemines LNG and extending out 50 kilometers. 50 kilometers is the maximum distance accepted by USEPA for the use of the AERMOD dispersion model.[8]

A flagpole height of 1.5 meters was not used for all modeled receptors.
Elevations for receptors were obtained from National Elevation Dataset (NED) GeoTiff data. GeoTiff is a binary file that includes data descriptors and geo-referencing information necessary for extracting terrain elevations. These elevations were extracted from 1 arc-second (30 meter) resolution NED files. The USEPA software program AERMAP v. 18081 is used for these tasks.

4.5 Meteorological Data

The meteorological data for the updated modeling analysis was obtained from the same weather stations used for the 2020 TC modeling analysis. These data were processed using the most recent version of AERMET (v. 21112).

Procedures used for processing of the meteorological data would have been evaluated and approved by DEQ as part of the PSD air permit application review process.

4.5.1 Surface Meteorology

Surface meteorological data collected at the National Weather Service (NWS) station at the New Orleans International Airport for the period 2019-2021 was used to generate AERMOD-ready meteorological data.

4.5.2 Upper Air Data

Upper-air data are collected by a "weather balloon" that is released twice per day at selected locations. As the balloon is released, it rises through the atmosphere, and radios the data back to the surface. The measuring and transmitting device is known as either a radiosonde, or rawindsonde.

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[8] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, Section A.1.(1), November 9, 2005.

Data collected and radioed back include: air pressure, height, temperature, dew point, wind speed, and wind direction. The upper air data are processed through AERMET Stage 1, which performs data extraction and quality control checks.

Concurrent 2019-2021 upper air data from twice-daily radiosonde measurements obtained at the most representative location were used. Upper air data were obtained from the Slidell, Louisiana measurement station.

4.5.3 AERSURFACE

AERSURFACE is a program that extracts surface roughness, albedo, and daytime Bowen ratio for an area surrounding a given location. AERSURFACE uses land use and land cover (LULC) data in the U.S. Geological Survey's National Land Cover Dataset to extract the necessary micrometeorological data including land cover, canopy and impervious surfaces. The current version of AERSURFACE v. 20060. It was assumed that annual moisture was average and there was no snow cover during the winter months.

4.5.4 Data Review

Missing meteorological data were not filled as the data file met USEPA's 90% data completeness requirement.[9] The AERMOD output file shows there were 0.79% missing data across the entire 2019-21 meteorological period.

5. Background NO_2 Concentrations

Similar to the 2020 modeling report submitted by TC to DEQ, a fixed background NO2 concentration was obtained from the ambient monitoring station (Monitor ID 22-051-1001) located in Kenner, Louisiana.

6. Reporting

All files from the programs used for this modeling analysis are available to regulatory agencies.

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[9] USEPA, Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-05, February 2000, Section 5.3.2, pp. 5-4 to 5-5.